THE

POPULAR SCIENCE MONTHLY.

DECEMBER, 1877.

THE GROWTH OF THE STEAM-ENGINE.[1]

By Professor R. H. THURSTON,
of the Stevens Institute of Technology.

II.

THE STEAM-ENGINE AS A TRAIN OF MECHANISM.

SECTION III. *The Period of Development.* Newcomen and Watt, A. D. 1700 to A. D. 1800.—22. The evident defects of Savery's engine, its extravagant consumption of fuel, the inconvenient necessity of placing it near the bottom of the mine to be drained, and of putting in several for successive lifts where the depth was considerable, and, especially, the risk which its use with high pressures involved even in its best form, considerably retarded its introduction, and it came into use very slowly, notwithstanding its superiority in economic efficiency over horse-power.

23. The first important step taken toward remedying these defects was by Thomas Newcomen and John Cawley, or Calley, two mechanics of the town of Dartmouth, Devonshire, England, who produced what has been known as the Atmospheric or Newcomen Engine.

Newcomen was a blacksmith, and Cawley a glazier and plumber.

It has been stated that a visit to Cornwall, where they witnessed the working of a Savery engine, first turned their attention to the subject; but a friend of Savery has stated that Newcomen was as early with his general plans as Savery.

After some discussion with Cawley, Newcomen entered into correspondence with Dr. Hooke, proposing a steam-engine, to consist of a

[1] An abstract of "A History of the Growth of the Steam-Engine," to be published by D. Appleton & Co.

steam-cylinder containing a piston similar to those of Huyghens's and Papin's engines, and driving a separate pump, similar to those generally in use where water was raised by horse or wind power.

Dr. Hooke advised and argued strongly against their plan; but, fortunately, the obstinate belief of the unlearned mechanics was not

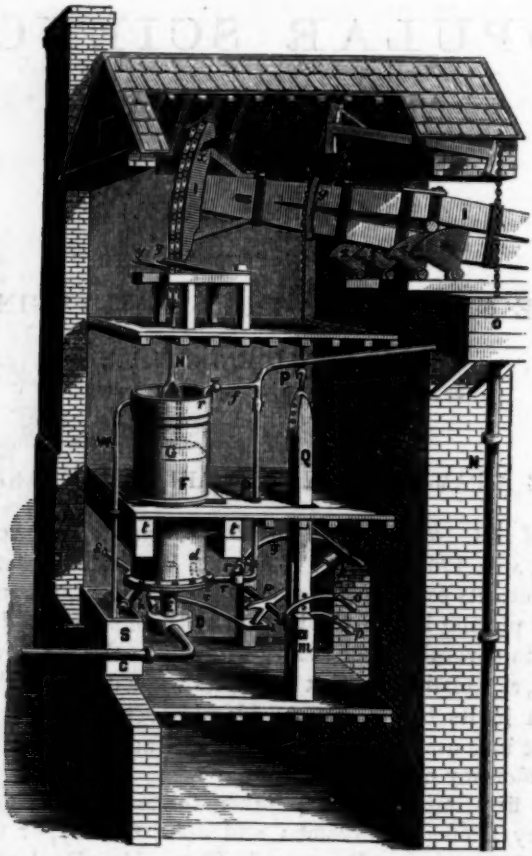


FIG. 10.—THE NEWCOMEN ENGINE, AS IMPROVED BY SMEATON, 1775.

overpowered by the disquisitions of their distinguished correspondent, and Newcomen and Cawley attempted an engine on their peculiar plan.

This succeeded so well as to induce them to continue their labors, and in 1705 to patent[1]—in combination with Savery, who held the right of surface condensation, and who induced them to allow him an interest with them—an engine combining a steam-cylinder and piston, surface condensation, and a separate boiler and separate pumps.

[1] It has been denied that a patent was issued; but there is no doubt that Savery claimed and received an interest in the new engine.

24. In the atmospheric engine as first designed, the slow process of condensation by the application of the condensing water to the exterior of the cylinder to produce the vacuum caused the strokes of the engine to take place at very long intervals. An improvement was, however, soon effected, which immensely increased this rapidity of condensation. A jet of water was thrown directly *into* the cylinder, thus effecting for the Newcomen engine just what Desaguliers had previously done for the Savery engine. As thus improved, the Newcomen engine is shown in Fig. 11.

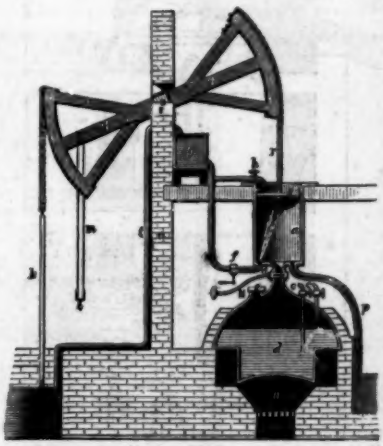


Fig. 11.—Newcomen's Engine, A. D. 1705.

Here *d* is the boiler. Steam passes from it through the cock *d*, and up into the cylinder *a*, equilibrating the pressure of the atmosphere, and allowing the heavy pump-rod *k* to fall, and, by its greater weight, acting through the beam *i i*, to raise the piston *s* to the position shown.

The cock *d* being shut, *f* is then opened, and a jet of water from the reservoir *g* enters the cylinder, producing a vacuum by the condensation of the steam. The pressure of the air above the piston now forces it down, again raising the pump-rods, and thus the engine works on indefinitely.

The pipe *h* is used for the purpose of keeping the upper side of the piston covered with water, to prevent air-leaks—a device of Newcomen.

Two gauge-cocks, *c*, *c*, and a safety-valve, *N*, are represented in the figure, but it will be noticed that the latter is quite different from the now usual form. Here, the pressure used was hardly greater than that of the atmosphere, and the weight of the valve itself was ordinarily sufficient to keep it down. The rod *m* was intended to carry a counter-weight when needed.

The condensing water, together with the water of condensation, flows off through the open pipe *p*. Newcomen's first engine made six or eight strokes a minute; the later and improved engines made ten or twelve.

25. The steam-engine has now assumed a form that somewhat resembles the modern machine.

An important defect still existed in the necessity of keeping an attendant by the engine to open and shut the cocks. A bright boy, however, Humphrey Potter, to whom was assigned this duty on a Newcomen engine in 1713, contrived what he called a *scoggan*—a

catch rigged with a cord from the beam overhead—which performed the work for him.

The boy, thus making the operation of the valve-gear automatic, increased the speed of the engine to fifteen or sixteen strokes a minute, and gave it a regularity and certainty of action that could only be obtained by such an adjustment of its valves.

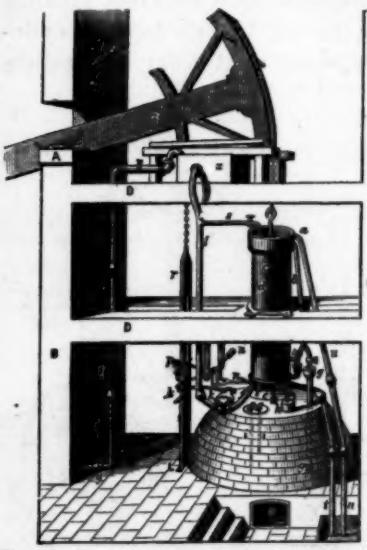


Fig. 12.—Beighton's Valve-Gear, a. d. 1718.

This ingenious young mechanic afterward became a skillful workman, and an excellent engineer, and went abroad on the Continent, where he erected several fine engines.

26. Potter's rude valve-gear was soon improved by Henry Beighton, and the new device was applied to an engine which that talented engineer erected at Newcastle-on-Tyne in 1718, in which engine he substituted substantial materials for Potter's unmechanical arrangement of cords, as seen in Fig. 12.

In this sketch, *r* is a plug-tree, plug-rod, or plug-frame, as it is variously called, suspended from the great beam with which it rises and falls, bringing the pins *p* and *k*, at the proper moment, in contact with the handles *k k* and *n n* of the valves, moving them in the proper direction and to the proper extent. A lever safety-valve is here used, at the suggestion (it is said) of Desaguliers.

The piston was packed with leather or with rope, and lubricated with tallow.

27. Further improvements were effected in the Newcomen engine by several engineers, and particularly by Smeaton, and it soon came into quite extensive use in all of the mining districts of Great Britain, and it also became generally known upon the Continent of Europe.

Its greater economy of fuel as compared with the Savery engine in its best form, its greater safety—a consequence of the low steam-pressure adopted—and its greater working capacity, gave it such manifest superiority that its adoption took place quite rapidly, and it continued in general use in some districts where fuel was cheap up to a very recent date. Some of these engines are even now in existence.

From about 1758 to the time of the introduction of the Watt engine, this was the machine in almost universal use for raising large quantities of water.

28. The success of the Newcomen engine naturally attracted the attention of mechanics, and of scientific men as well, to the possibility of making other applications of steam-power.

The greatest men of the time gave much attention to the subject; but, until JAMES WATT began the work that has made him famous, nothing more was done than to improve the proportions and to slightly alter the details of the Newcomen and Cawley engine, even by such skillful engineers as Brindley and Smeaton.

Of the personal history of the earlier inventors and improvers of the steam-engine very little is known; but that of Watt has been fully traced.

29. This great man was born at Greenock, then a little Scotch fishing-village, but now a considerable and a busy town, which annu-

JAMES WATT.

ally launches upon the waters of the Clyde a fleet of steamships whose engines are probably, in the aggregate, far more powerful than were all the engines in the world at the date of Watt's birth—January 19, 1736.

He was a bright boy, but exceedingly delicate in health, and quite unable to attend school regularly, or to apply himself closely to either study or play.

His early education was given by his parents, who were respectable and intelligent people, and the tools borrowed from his father's carpenter's-bench served at once to amuse him and to give him a dexterity and familiarity with their use that must undoubtedly have been of inestimable value to him in after-life.

M. Arago, the eminent French philosopher, who wrote one of

the earliest and most interesting biographies of Watt, relates anecdotes of him which, if correct, illustrate well the thoughtfulness and the intelligence, as well as the mechanical bent, of the boy's mind.

He is said, at the age of six years, to have occupied himself during leisure hours with the solution of geometrical problems, and Arago discovers in a story, in which he is described as experimenting with the tea-kettle, his earliest investigations of the nature and properties of steam.

When finally sent to the village-school, his ill-health prevented his making rapid progress, and it was only when more than fourteen years of age that he began to show that he was capable of taking the lead in his class, and to exhibit his ability in the study particularly of mathematics. His spare time was principally spent in sketching with his pencil, in carving, and in working at the bench, both in wood and metal. His favorite work seemed to be the repairing of nautical instruments.

In boyhood, as in after-life, he was a diligent reader, and he seemed to find something to interest him in every book that came into his hands.

At the age of eighteen Watt was sent to Glasgow, there to reside with his mother's relatives, and to learn the trade of a mathematical-instrument maker. The mechanic with whom he was placed was soon found too indolent, or was otherwise incapable of giving much aid in the project; and Dr. Dick, of the University of Glasgow, with whom Watt became acquainted, advised him to go to London.

Accordingly, he set out in June, 1755, for the metropolis, where, on his arrival, he arranged with Mr. John Morgan, in Cornhill, to work for a year at his chosen business, receiving as compensation twenty guineas. At the end of the year he was compelled by serious ill-health to return home.

30. Having become restored to health, he went again to Glasgow, in 1756, with the intention of pursuing his calling there. But not being the son of a burgess, and not having served his apprenticeship in the town, he was forbidden by the guilds, or trades-unions, to open a shop in Glasgow. Dr. Dick came to his aid, and employed him to repair some apparatus which had been bequeathed to the college; and he was finally allowed the use of three rooms in the university-building, its authorities not being under the municipal rule.

He remained here until 1760, when, the trades no longer objecting, he took a shop in the city, and in 1761 moved again into a shop on the north side of the Trongate, where he earned a scanty living without molestation, still keeping up his connection with the college.

He spent much of his leisure time, of which he had more than was desirable, in making philosophical experiments, and in the manu-

facture of musical instruments, making himself familiar with the sciences, and devising improvements in the construction of organs.

His reading was still very desultory; but the introduction of the Newcomen engine in the neighborhood of Glasgow, and the presence of a model in the college collections, which model was placed in his hands in 1763 for repairs, led him to study the history of the steam-engine, and to conduct for himself an experimental research into the properties of steam, using a set of improvised apparatus.

31. The Newcomen model, as it happened, had a boiler, which, although made to a scale from engines in actual use, was quite incapable of furnishing steam enough to work the engine.

It was about nine inches in diameter, and the steam-cylinder was two inches in diameter, and of six inches stroke of piston, arranged as in Fig. 13.

This is a picture of the most carefully-preserved treasure in the collections of the University of Glasgow. Watt at once noticed the defect referred to, and immediately sought first the cause and then the remedy.

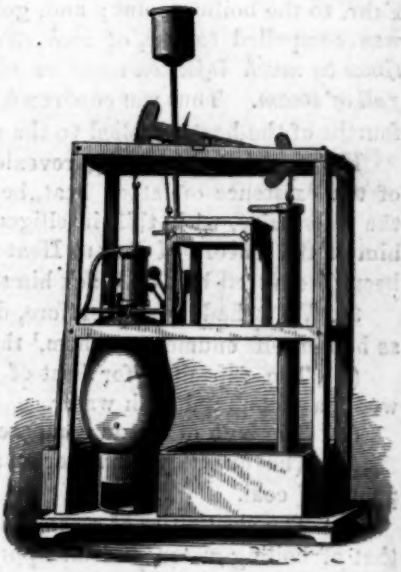


FIG. 13.—THE NEWCOMEN MODEL.

32. He soon concluded that the sources of loss of heat in the Newcomen engine—which loss would be greatly exaggerated in a small model—were: first, the dissipation of heat by the cylinder itself, which was of brass, and was both a good conductor and a good radiator; secondly, the loss of heat consequent upon the necessity of cooling down the cylinder at every stroke in producing the vacuum; and, finally, a loss of power was due to the existence of vapor beneath the piston, the presence of which vapor was a consequence of the imperfect method of condensation which characterizes the Newcomen engine.

He first made a cylinder of non-conducting material—wood soaked in oil and then baked—and found a decided advantage in the economy of steam thus secured.

He then conducted a series of experiments upon the temperature and pressure of steam at such points in the scale as he could readily reach, and, constructing a curve with his results, the abscissas representing temperatures, and the pressures being represented by the ordinates, he ran the curve backward until he had obtained approxi-

mate measures of temperatures less than 212°, and of pressures less than atmospheric.

He thus discovered that, with the amount of injection-water used in the Newcomen engine, bringing the temperature of the interior, as he found, down to from 140° to 175° Fahr., a very considerable back-pressure would be met with.

Continuing his research still further, he measured the amount of steam used at each stroke; and, comparing it with the quantity that would just fill the cylinder, he found that *at least three-fourths was wasted.*

The quantity of cold water necessary to produce condensation of a given weight of steam was next determined, and he found that one pound of steam contained enough heat to raise about six pounds of cold water, as used for condensation, from the temperature of 52° Fahr. to the boiling-point; and, going still further, he found that he was compelled *to use, at each stroke of the Newcomen engine, four times as much injection-water as should suffice to condense a cylinder full of steam.* Thus was confirmed his previous conclusion that three-fourths of the heat supplied to the engine was wasted.

His experiments having revealed to him the now well-known fact of the existence of latent heat, he went to his friend Dr. Black, of the university, with this intelligence; and the latter then informed him of the Theory of Latent Heat which had but a short time earlier been discovered by Dr. Black himself.

33. Watt had now, therefore, determined by his own researches, as he himself enumerates them,[1] the following facts:

(1.) The capacities for heat of iron, copper, and of some sorts of wood, as compared with water.

(2.) The bulk of steam compared with that of water.

(3.) The quantity of water evaporated in a certain boiler by a pound of coal.

(4.) The elasticities of steam, at various temperatures greater than that of boiling water, and an approximation to the law which it follows at other temperatures.

(5.) How much water, in the form of steam, was required, at every stroke, by a small Newcomen engine, with a wooden cylinder six inches in diameter and twelve inches stroke.

(6.) The quantity of cold water required, at every stroke, to condense the steam in that cylinder, so as to give it a working power of about seven pounds on the square inch.

34. After these well-devised and truly scientific investigations, Watt was enabled to enter upon his work of improving the steam-engine with an intelligent understanding of its existing defects, and with a knowledge of their cause.

It was on a Sunday afternoon, in the spring of 1765, that he de-

[1] Robinson's "Mechanical Philosophy," edited by Brewster.

vised his first and his greatest invention—the separate condenser. His object in using it was, as he says himself, *to keep the cylinder as hot as the steam that entered it.* He was therefore the first to apprehend and to state a problem which the modern engineer is still vainly endeavoring completely to solve.

Watt was, at this time, twenty-nine years of age. Having taken this first step and made such a radical improvement, the success of the invention was no sooner determined than others followed in rapid succession as consequences of the exigencies arising from the first radical change in the old Newcomen engine.

But in the working out of the forms and proportions of details in the new engine, even Watt's powerful mind, with its stores of happily-combined scientific and practical information, was occupied for years.

35. In attaching the separate condenser, he first tried surface condensation, as in Fig. 14, which is a sketch of his first model; but this not succeeding well, he substituted the jet. Some provision became at once necessary for preventing the filling of the condenser with water.

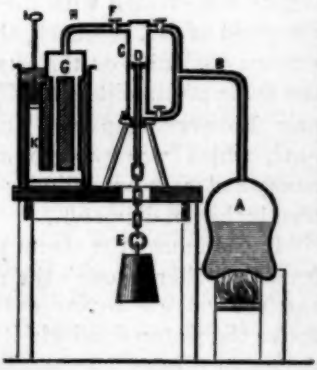


FIG. 14.—WATT'S FIRST MODEL, 1765.

Watt at first intended adopting the same expedient which worked satisfactorily with the less effective condensation of Newcomen's engine, i. e., leading a pipe from the condenser to a depth greater than the height of the column of water which could be counterbalanced by the pressure of the atmosphere; but he subsequently employed the air-pump, which relieves the condenser, not only of the water, but of the air which also usually collects in considerable volume, and vitiates the vacuum.

He next substituted oil and tallow for the water previously used in lubrication of the piston and keeping it steam-tight, in order to avoid the cooling of the cylinder incident to the use of water.

Still another cause of refrigeration of the cylinder, and consequent waste of power in its operation, was seen to be the entrance of the atmosphere, which came in at the top and followed the piston down the cylinder at each stroke.

This the inventor concluded to prevent by covering the top of the cylinder, and allowing the piston-rod to play through a "stuffing-box," which device had long been known to mechanics. He accordingly not only covered the top, but surrounded the whole cylinder with an external casing or "steam-jacket," and allowed the steam from the boiler to pass around the steam-cylinder and to press upon the upper

surface of the piston where its pressure was readily variable, and therefore more manageable than that of the atmosphere. It also, besides keeping the cylinder hot, could do comparatively little harm should it leak by the piston, as it might be condensed and readily disposed of.

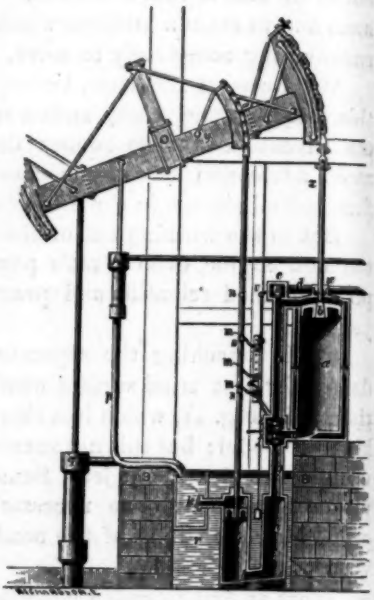


Fig. 15.—Watt's Pumping-Engine, A. D. 1769.

36. This completed the change of the "atmospheric engine" of Newcomen into the steam-engine of James Watt. The engine as improved is shown in Fig. 15, which represents the engine as patented in April, 1769. Watt's first engine was erected with the pecuniary aid of Dr. Roebuck, the lessor of a coal-mine on the estate of the Duke of Hamilton, at Kinneil, near Borrowstounness. This engine, which was put up at the mine, had a steam-cylinder eighteen inches in diameter.

In the figure, the steam passes from the boiler through the pipe *d* and the valve *c* to the cylinder casing, or steam-jacket, *Y Y*, and above the piston *b*, which it follows in its descent in the cylinder *a*, the valve *f* being at this time open to allow the exhaust to pass into the condenser *h*.

The piston now being at the lower end of the cylinder, and the pump-rods at the opposite end of the beam *y* thus raised, and the pumps filled with water, the valves *c* and *f* close, while *e* opens, allowing the steam which remains above the piston to flow beneath it, until, the pressure becoming equal above and below by the weight of the pump, it is rapidly drawn to the top of the cylinder, while the steam is displaced above, passing to the underside of the piston.

Now the valve *e* is closed, and *c* and *f* are again opened, and the down-stroke is repeated as before. The water and air entering the condenser are removed, at each stroke, by the air-pump *i*, which communicates with the condenser by the passage *s*. The pump *q* supplies condensing-water, and the pump *A* takes away a part of the water of condensation, which is thrown by the air-pump into the "hot well" *k*, and with it supplies the boiler. The valves are moved by valve-gear very similar to Beighton's, by the pins *m m* in the "plug-frame" or "tappet-rod" *n n*.

The engine is mounted upon a substantial foundation, *B B*. *F* is

an opening, out of which, before starting the engine, the air is driven from the cylinder and condenser.

37. In the building and erection of his engines, Watt had the greatest difficulty in finding skillful workmen to make the parts with accuracy, to fit them with skill, and to erect them properly when once finished.

The fact that both Newcomen and Watt found such serious trouble indicates that, even had the engine been designed earlier, it is quite unlikely that the world would have seen the steam-engine a success until this period, when mechanics were just acquiring the skill requisite for its construction. But, on the other hand, it is not at all certain that, had the mechanics of an earlier period been as skillful and as well educated in the manual niceties of their business, the steam-engine might not have been much earlier brought into use.

In the time of the Marquis of Worcester, it would have probably been found impossible to obtain workmen to construct the steam-engine of Watt, had it been then invented. Indeed, Watt, upon one occasion, congratulated himself that one of his steam-cylinders *only lacked three-eighths of an inch* of being truly cylindrical.

38. Pecuniary misfortunes soon deprived Watt of the assistance

MATTHEW BOULTON.

of his friend and partner Dr. Roebuck, but in 1773 he became connected with an intelligent, energetic, and wealthy manufacturer of Birmingham, Matthew Boulton. Thenceforward, the establishment

of Boulton & Watt, at Soho, near Birmingham, for a long time furnished the greater proportion of all the steam-engines made in the world.

In the new firm, Boulton took charge of the general business, and Watt superintended the design, construction, and erection, of their engines. Boulton's business capacity, with Watt's wonderful mechanical ability; Boulton's physical health, and his vigor and courage, offsetting Watt's feeble health and depression of spirits; and, more than all, Boulton's pecuniary resources, both in his own purse and in the wealth of his friends, enabled the firm to conquer all difficulties, whether in finance, in litigation, or in engineering.

39. Watt had, before meeting Boulton, conceived the idea of economizing some of that power the loss of which was so plainly indicated by the violent rush of the exhaust steam into the condenser, and had described the advantages that would follow the use of steam expansively, by means of a "cut-off," in a letter to Dr. Small, of Birmingham, dated Glasgow, May, 1769. He had also planned a "compound engine."

This invention of the expansion of steam, which, in importance, was hardly exceeded by any other improvement of the steam-engine, was adopted at Soho in 1776, but the patent was not obtained until 1782.

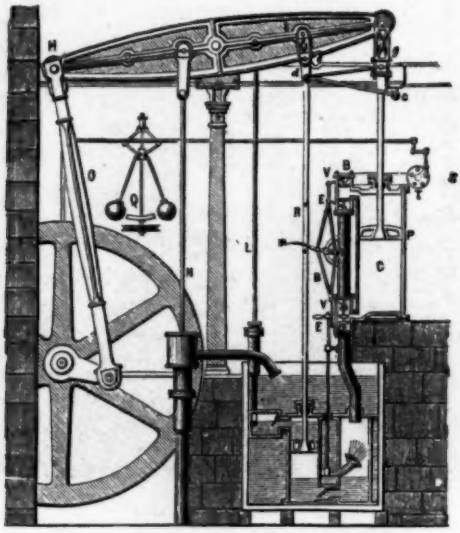


Fig. 16.—Watt's Steam-Engine, A. D. 1780.

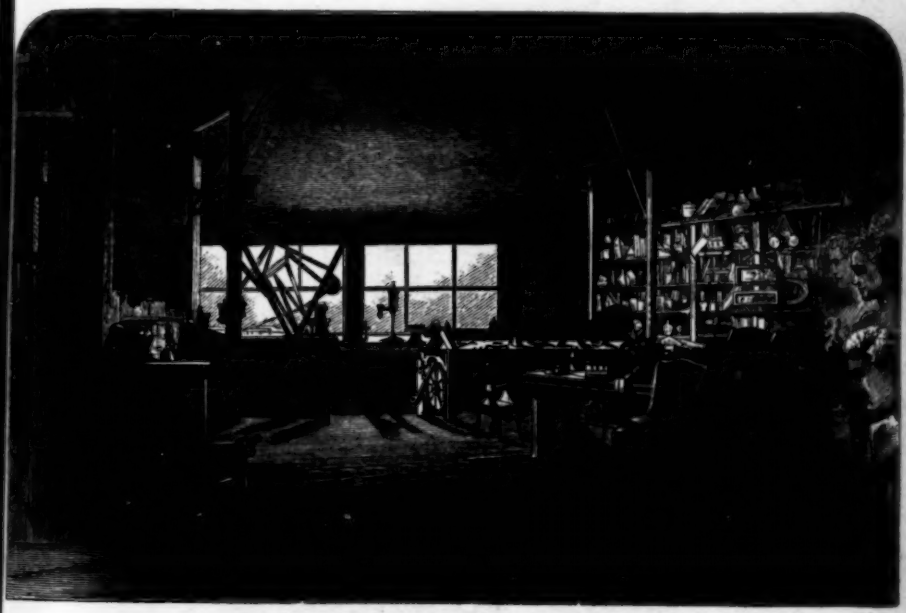
During this interval, Watt invented the crank and fly-wheel, but, as the former had been first patented by Wasborough, who is supposed to have obtained a knowledge of it from workmen employed by Watt, the latter patented several other methods of producing

rotary motions, and temporarily adopted that known as the "sun-and-planet wheels," subsequently using the crank.

The adaptation of the steam-engine to the production of rotary motion was soon succeeded by the introduction of the Double-Acting Engine, the Fly-ball Governor, the Counter, the Steam-Engine Indicator, and other minor but valuable improvements, which were the final steps by which the Watt steam-engine became applicable to driving mills, to use on railroads, to steam-navigation, and to the countless purposes by which it has become, as it has already been denominated, the great material agent of civilization.

40. Fig. 16 represents the Watt Double-Acting engine. It will be noticed that it differs from the Single-Acting engine in having steam-valves, *B B*, and exhaust-valves, *E E*, at each end of the cylinder, thus enabling the steam to act on each side of the piston alternately, and practically doubling the power of the engine.

The end of the beam opposite to the cylinder is usually connected with a crank-shaft.



WATT'S WORKSHOP AT HOME.

41. At this point, the history of the steam-engine becomes the story of its applications in several different directions, the most important of which are the raising of water, which has hitherto been its only application; the propulsion of carriages, as in the locomotive-engine; the driving of mills and machinery; and steam-navigation.

Here we take leave of James Watt, of whom a French author[1] says, "The part which he played, in the mechanical application of the power of steam, can only be compared to that of Newton in astronomy, and of Shakespeare in poetry."

Retiring from the firm in the first year of the present century, Watt remained quietly on his estate at Heathfield. He fitted up a little workshop in his house, and there spent nearly all his time, inventing, designing, and constructing ingenious machines for special purposes. He died peacefully, full of years and great in fame, August 25, 1819.

Since the time of Watt, improvements have been principally in matters of mere detail, and in the extension of the range of application of the steam-engine.

42. To complete the history of its application to raising water, the succeeding figures are given as exhibiting the principal forms of pumping-engine as now constructed.

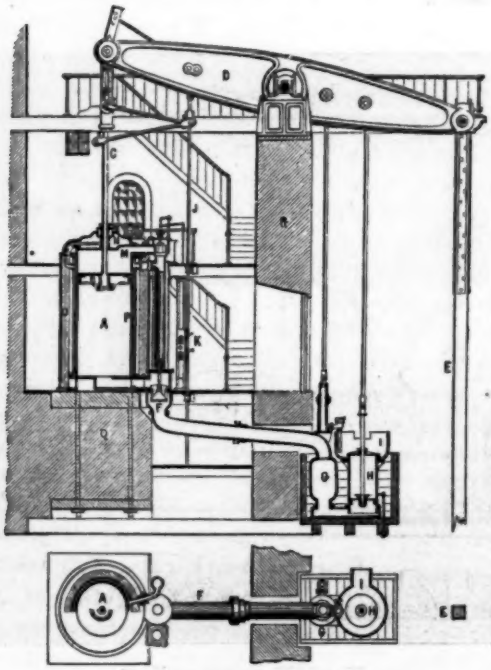


FIG. 17.—THE CORNISH PUMPING-ENGINE, 1877.

Fig. 17 represents the Cornish pumping-engine, which, in spite of its great weight and high cost, is still much used.

It will be seen that it is the engine of James Watt in all its general features.

[1] "Traité des Machines à Vapeur," E. M. Bataille, Paris, 1847.

It is single-acting, and has a steam-jacket and a plug-rod valve-gear, *J K*. The improvements are principally in the form and proportions of its parts, and in its adaptation to high steam and "short 'cut-off.'"

A is the steam-cylinder, *B C* the piston and rod, *D* the beam, and *E* the pump-rod. The condenser is seen at *G*, and the air-pump at *H*. The steam-cylinder is "steam-jacketed," and is surrounded by a casing, *O*, composed of brickwork or other non-conducting material. Steam is first admitted above the piston, driving it rapidly downward and raising the pump-rod. At an early point in the stroke the admission of steam is checked by the sudden closing of the induction-valve, and the stroke is completed under the action of expanding steam assisted by the inertia of the heavy parts already in motion. The necessary weight and inertia are afforded in many cases, where the engine is applied to the pumping of deep mines, by the immensely long and heavy pump-rods. Where this weight is too great, it is counterbalanced; and where, as when used for the water-supply of cities, too small, weights are added. When the stroke is completed, the "equilibrium-valve" is opened, and the steam passes from above to the space below the piston, and, an equilibrium of pressure being thus produced, the pump-rods descend, forcing the water from the pumps and raising the steam-piston. The absence of the crank or other device which might determine absolutely the length of stroke compels a very careful adjustment of steam admission to the amount of load. Should the stroke be allowed to exceed the proper length, and should danger thus arise of the piston striking the cylinder-heads, the movement is checked by buffer-beams. The regulation is effected by a "cataract," a kind of hydraulic governor, consisting of a plunger-pump with a reservoir attached. The plunger is raised by the engine, and then automatically detached. It falls with greater or less rapidity, its velocity being determined by the size of the eduction orifice, which is adjustable by hand. When the plunger reaches the bottom of the pump-barrel, it disengages a catch, a weight is allowed to act upon the steam-valve, opening it, and the engine is caused to make a stroke. When the outlet of the cataract is nearly closed, the engine stands still a considerable time while the plunger is descending, and the strokes succeed each other at long intervals. When the opening is greater, the cataract acts more rapidly, and the engine works faster. This has been regarded until recently as the most economical of pumping-engines, and it is still generally used in Europe in freeing mines of water.

43. Fig. 18 represents a lighter, cheaper, and almost equally effective machine, known as the Bull Cornish or Direct-Acting Cornish engine. It was first designed by the competitor of Watt, by whose name it is known. As is seen by reference to the engraving, its cylinder *a* is directly above the pump-rods *c*, *d*, *g*, and is carried on

cross-beams, *b b*. The air-pump *m l o p*, the tank *n*, and valve-gear *q r s*, are quite similar to those of the beam Cornish engine. The balance-beam is seen at *h i*.

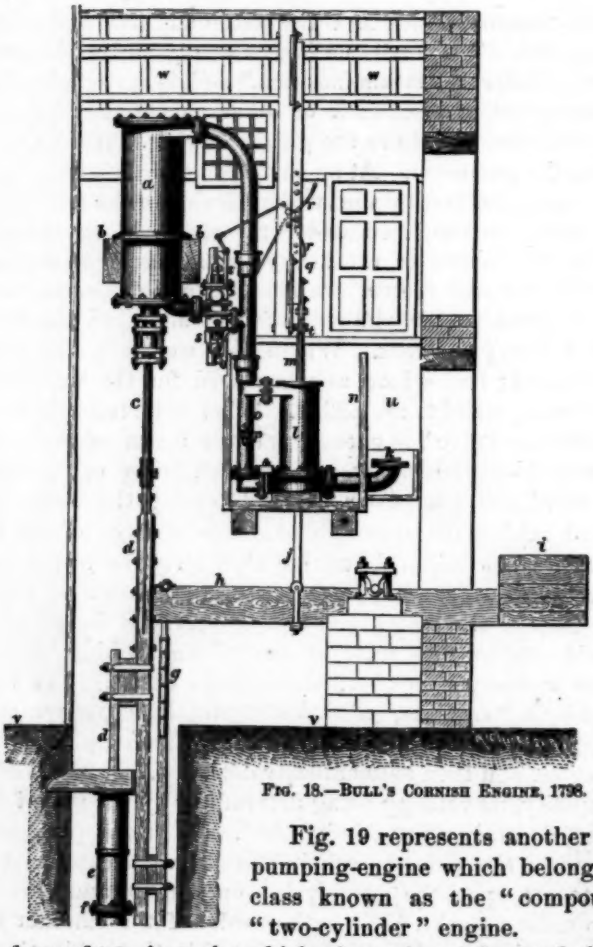


FIG. 18.—BULL'S CORNISH ENGINE, 1798.

Fig. 19 represents another form of pumping-engine which belongs to the class known as the "compound" or "two-cylinder" engine.

This class of engines, in which the steam exhausted from one cylinder is further expanded in the second, was first introduced by Hornblower, in 1781, and was patented, in combination with the Watt condenser, by Woolf, at a later date (1804), with a view to adopting high steam and considerable expansion.

The Woolf engine was to some extent adopted, but was not successful in competing with Watt engines where the latter were well built, and, like Hornblower's engine, was soon given up.

The compound engine has come up again within a few years, and, with what is *now* considered high steam and considerable expansion, and designed with more intelligent reference to the requirements of

economy in working steam in this manner, it seems gradually displacing all other forms of engine.

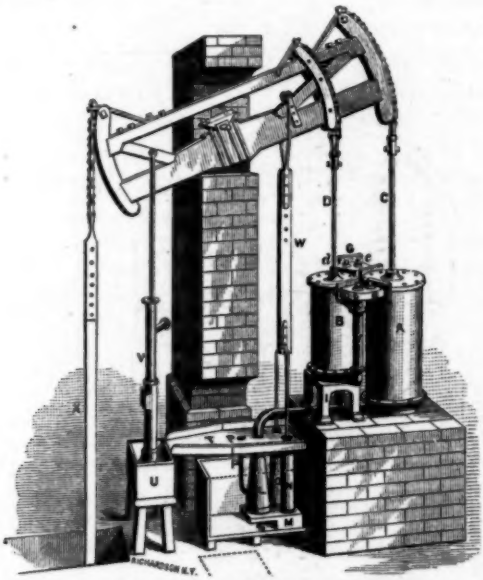


FIG. 19.—HORNBLOWER'S COMPOUND ENGINE, 1781.

44. An example of this form of pumping-engine, and one which is a favorite with many engineers, is the beam and crank engine (Fig.

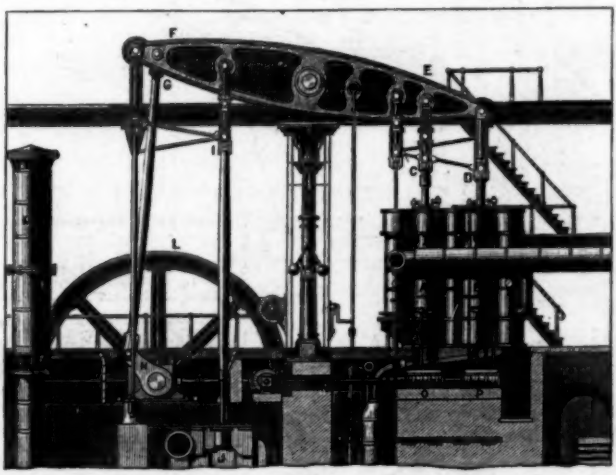


FIG. 20.—COMPOUND PUMPING-ENGINE, 1860.

20), *C D*, *E F*, with double cylinder, *A*, *B*, working the "combined bucket and plunger," or double-acting pump, *J*. In its cylinders steam

is usually expanded from four to eight times. The Leavitt compound engine is shown in Fig. 21.

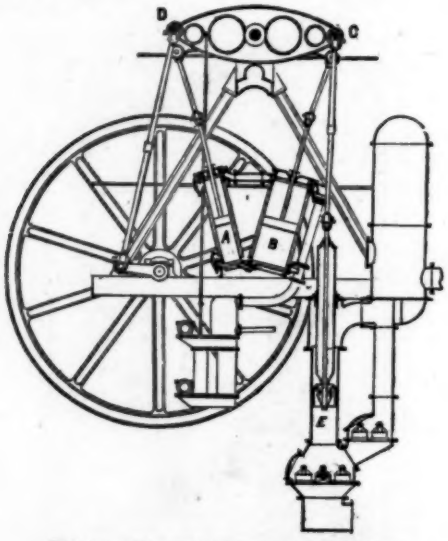


FIG. 21.—LEAVITT'S PUMPING-ENGINE, 1875.

In this engine the lower ends, *A*, *B*, of the two cylinders are brought close together under the centre of the beam, thus shortening

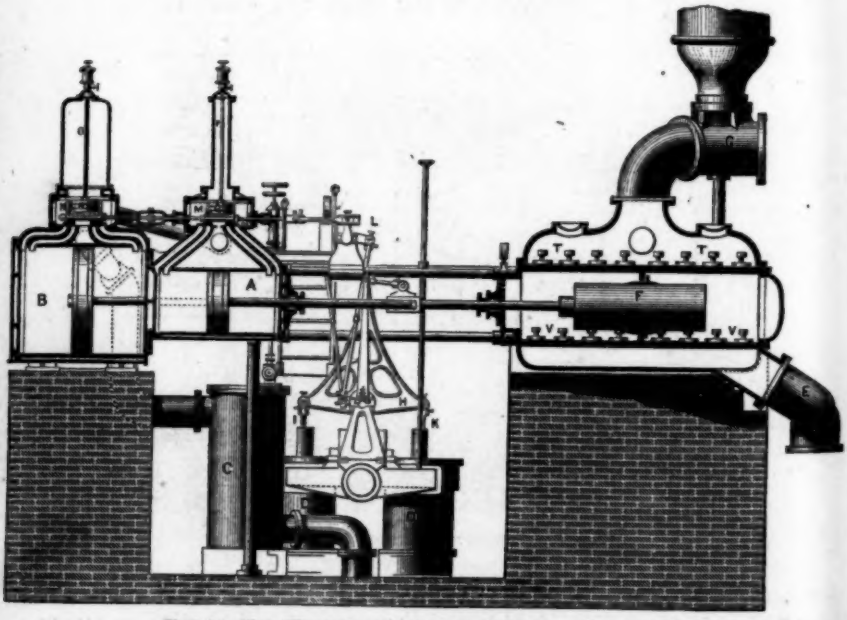


FIG. 22.—THE WORTHINGTON COMPOUND PUMPING-ENGINE, 1870.

the steam-passages between them, permitting a symmetrical distribution of strain, and the use of the usual general type of beam-engine. A readily-adjustable valve-gear is attached, and its cut-off gives an expansion of about ten times, the boiler steam-pressure being about eighty pounds per square inch. The cylinders are steam-jacketed, and very thoroughly clothed with a non-conducting felting and lagging. This engine has given the best economical results yet reported in this country, attaining a "duty" on a test-trial of more than 100,000,000 pounds of water raised one foot high by each 100 pounds of fuel burned.

Still another recent form of steam pumping-engine, noted for its cheapness combined with efficiency, is that of Worthington (Fig. 22), in which two pairs of steam cylinders, *A*, *B*, are placed side by side, each pair driving a pump-plunger, *F*, attached to its piston-rod, and each having its valve-gear, *H L*, *M N*, actuated by the movement of the piston of the other. The cylinders together form a compound engine; the steam exhausted from the smaller, *A*, passing into the

TOMB OF JAMES WATT, HANDSWORTH CHURCH, 1819.

larger, *B*, where it is further expanded. The valve-gear of this engine is peculiarly well adapted to this type of engine. There is no fly-wheel, and the motion of each of the two independent engines, which together form the pair, is controlled by its neighbor, the valve-gear of the one being moved by the piston of the other. This ingenious combination permits each piston to move from end to end of its cylinder, holds it stationary an instant while the pump-cylinders be-

come completely filled and their valves closed, and then sets it in motion on the return-stroke. Thus the pistons move alternately. These engines have given a very high duty. The condenser is seen at *C*, and the air-pump is at *D*, the latter being worked from the bell-crank lever *H* by means of links, *I*, *K*. The steam-valves, *Q*, *R*, are balanced. *V V* are the water-induction valves, and *T' T'* those on the eduction-side.

Here we leave the steam-engine as applied to raising water. We have invariably noticed, in the forms of engines so used, that a condenser forms a part of the apparatus.

We will next briefly trace the history of that now familiar form of engine in which the steam, having done its work, is discharged directly into the atmosphere.

STAR OR STAR-MIST.

By RICHARD A. PROCTOR.

A REMARKABLE discovery has been made by the astronomers of Lord Lindsay's observatory at Dunecht—a discovery the true meaning of which is not as yet fully perceived. It may be remembered that some nine months ago a new star, as it was called, made its appearance in the constellation Cygnus.[1] This object shone out where before no star had been known to astronomers—not merely, be it noticed, where there was no visible star, but where none was recorded even in lists like Argelander's "Durchmusterung," containing hundreds of thousands of telescopic stars. It was not, however, altogether impossible that some small star within moderate telescopic range had existed in the spot where the new star shone out, and that in some way this small star had escaped observation. This seemed the more likely because the new star had appeared in a part of the heavens very rich indeed in telescopic stars; at any rate, astronomers had reason to believe that they would be readily able to determine the question with a high degree of probability by watching the star as it gradually faded out of view. For a "new star" which had shone out in the constellation of the Northern Crown in May, 1866, and had been identified with a tenth-magnitude star in Argelander's list, had gradually faded out of view, and, growing yet fainter, had sunk through one telescopic magnitude after another until it shone again as a tenth-magnitude star only. Since that star had resumed its former lustre, or rather its former faintness, it seemed not unreasonable to conclude that so also would the star in Cygnus. We shall presently see how far this expectation was from being fulfilled.

[1] *See* POPULAR SCIENCE MONTHLY, vol. xi., p. 59.

During its time of greatest observed brilliancy the new star in the Swan was very carefully watched by spectroscopists. The results were in many respects interesting. The star in the Crown had shown the bright lines of hydrogen, superposed upon a faint rainbow-tinted spectrum, which was understood to signify that around a real, though probably a small, sun, some outburst of glowing hydrogen had taken place, the chief part of the star's new light being due to this outburst. The same bright hydrogen lines were seen also in the case of the star in Cygnus. But in addition to them other bright lines were seen, which seemed to be identical with those belonging to the solar sierra (or, as many astronomers unclassically call it, the chromosphere) and corona. This, at least, was the opinion of M. Cornu, of the Paris Observatory. Herr Vogel, who began his observations on December 5th, when the star was between the fourth and fifth magnitude, and continued them to March 10th, when the star had sunk below the eighth magnitude, does not agree on this point with M. Cornu, since a line not agreeing with any known line in the spectrum of the sun's sierra was clearly visible from the beginning in the spectrum of the new star. But the most interesting point in connection with Vogel's observations, confirmed also by Mr. Copeland, at the Dunecht Observatory, and by Mr. Backhouse, of Sunderland, was this: that, as the new star died out, not only did the rainbow-tinted background of the spectrum fade gradually out of view, but the relative lightness of the bright lines steadily changed. At last, on March 10th, very little was left of the spectrum which Cornu and Vogel had seen in December. The blue and violet portion of the spectrum had faded entirely from view, a dark gap had appeared in the green, and a very broad, dark band in the blue. Of the bright lines two only remained. One, the F line of hydrogen, in the green-blue, which had been singularly conspicuous last December, was now faint. The other, in the green, which had been faint in December, was now very bright—in fact, nearly the whole light of the star seemed at this time to come from this bright line.

Now, the changes which had thus far taken place were altogether unlike those which had been noticed in the case of the new star in the Northern Crown. As that star faded from view the bright lines indicative of glowing hydrogen died out, and only the ordinary stellar spectrum remained. In the case of the star in Cygnus the part of the spectrum corresponding to stellar light—that is to say, the rainbow-tinted streak crossed by dark lines—faded gradually from view, and bright lines only were left, at least as conspicuous parts of the star's spectrum. This body, then, did not seem to be returning to the stellar condition at all, but actually fading out into a nebula. Not only so, but the lines which still remained conspicuous last March were lines known to belong to the so-called gaseous nebulæ. One of them, that which had been the faintest, but was now the brightest, corre-

sponded to the nitrogen line of the nebular spectrum; the other, which was still conspicuous, though faint, corresponded to the hydrogen line of nebulæ.

That, however, was by no means the closing chapter of this singular history. Vogel seems to have ceased from observing the star's spectrum, strangely enough, at the very time when the most remarkable part of the process of change seemed to be approaching. At the Dunecht Observatory also, through pressure of work relating to Mars, no observations were made for nearly half a year. But, on September 3d, Lord Lindsay's 15-inch refractor was turned on the star. In the telescope a star was still shining, but with a faint blue color, utterly unlike that of the orb which had shone out so conspicuously last November. Under spectroscopic examination, however, the blue star was found to be no star at all, if we are to regard those orbs only as stars which present a spectrum in some degree analogous to that of our own sun. We regard Sirius as a sun, though in his spectrum the lines of hydrogen are abnormally strong; and, passing over the class of stars more closely resembling our sun, we regard as a true star the orange orb, Betelgeux, though the lines of hydrogen are wanting in its spectrum; nor do we reject from among the suns those stars which, like Gamma of Cassiopeia, show the lines of hydrogen bright upon a fainter rainbow-tinted spectrum. There is yet another order of stars —those whose spectrum presents bright bands with faintly lustrous intervals, which, again, we regard as true suns, though they differ doubtless notably from our own. But we have been in the habit of regarding all the star cloudlets, whether consisting of multitudinous stars, like the clusters, or of luminous star-mist, as differing *toto cœlo* from the sun and from all his fellow-stars. The clusters, indeed, give a spectrum resembling the sun's, and we regard them as different only because of their clustering condition. But the nebulæ which Sir W. Herschel regarded as consisting entirely of luminous vapor, and which spectroscopic analysis has proved to be so constituted, we have regarded not merely as different because of the structure and arrangement of their component parts, but as differing altogether in constitution. Now, the object seen as a faint blue star showed the same spectrum as these gaseous nebulæ, or rather as the very faintest of these nebulæ. For most of them show three bright lines, and one or two even show four bright lines; only the faintest shine with absolutely monochromatic or one-tint light. The star in Cygnus now shines like these faintest of the gaseous nebulæ—that is, with a light which, under spectroscopic analysis, presents only one bright line.

The words in which Lord Lindsay announced this remarkable discovery are these: "*There is little doubt but that this star has changed into a planetary nebula of small angular diameter*," though, he goes on to say, "such a result is in direct opposition to the nebular hypothesis." On this last point I venture to express dissent from Lord

Lindsay's opinion, which is in any case a somewhat bold inference from a single observation. Assuredly the discovery just made is in direct opposition to a certain argument, derived from the gaseity of nebulæ, in favor of the gaseous hypothesis of Laplace—an argument which had always appeared to the present writer insufficiently established. But the nebular hypothesis, regarded not merely in the form suggested by Laplace (in which form it was utterly inconsistent with physical facts now known), but in the wider sense which would simply present our solar system in the remote past as in a nebular state, without defining its nebulosity as due either to gaseity on the one hand, or to a mixed meteoric and cometic constitution on the other, has most certainly not received a shock, but rather receives strong support, from Mr. Copeland's observation. A theory of the evolution of the solar system, advocated by me during the last seven years, according to which the solar system had its origin in meteoric and cometic aggregation, requires that during the long ages through which the process of development continued there should be occasional outbursts of light and heat in moderate degree from the rest of the system, even to its outskirts. That intense heat imagined by Laplace as pervading the entire gaseous mass, extending originally far beyond the path of the remotest planet of our system, would require, indeed (if it were a physical possibility in other ways), that the spectrum of a developing solar system should be uniformly that of gaseity for millions on millions of years. If it had been found or could be proved that the gaseous nebulæ are in a state of intense heat, Laplace's gaseous hypothesis would have had one powerful argument in its favor. This argument has been strongly urged by those who have taken that special view of the gaseous nebulæ which the recent discovery shows to be erroneous. But those who have maintained, as I have, that in the gaseous nebulæ we probably "see vast systems of comets traveling in extensive orbits around nuclear stars," will find confirmation, not disproof, in the discovery lately made, especially when considered in combination with the circumstance that Prof. Wright, of Yale, has found the cometic spectrum to be emitted by meteoric masses exposed to moderate heat; while, under slight changes of condition, the cometic spectrum of bright carbon bands appears to give place to the nebular bright-line spectrum.

However, speculation apart, we have in the discovery just made a most important fact for our guidance—the fact, namely, that a body which to ordinary observation has been in all respects like the star in the Crown, and even under spectroscopic observation shone for a while with true stellar light, has dwindled into a nebula giving the spectrum which has heretofore been regarded as indicative of ordinary gaseity.—*English Mechanic.*

LANGUAGE AND THE ENGLISH CIVIL SERVICE.[1]

By ALEXANDER BAIN,
PROFESSOR OF LOGIC IN THE UNIVERSITY OF ABERDEEN.

THE system of competitive examinations for the public service, of which I have laid before the section a brief history compiled from the reports, is one of those radical innovations that may ultimately lead to great consequences. For the present, however, it leads to many debates. Not merely does the working out of the scheme involve conflicting views, but there is still great hesitation in many quarters as to whether the innovation is to be productive of good or of evil. The report of the Playfair Commission, and the more recent report relative to the changes in the India Civil Service regulations, indicate pretty broadly the doubts that still cleave to many minds on the whole question. It is enough to refer to the views of Sir Arthur Helps, Mr. W. R. Greg, and Dr. Farr, expressed to the Playfair Commission, as decidedly adverse to the competitive system. The authorities cited in the report on the India examinations scarcely go the length of total condemnation; but many acquiesce only because there is no hope of a reversal.

The question of the expediency of the system as a whole is not well suited to a sectional discussion. We shall be much better employed in adverting to some of those details in the conduct of the examinations that have a bearing on the whole education of the country, as well as on the Civil Service itself. It was very well, at first starting, for the commissioners to be guided, in their choice of subjects and in assigning values to those subjects, by the received branches of education in the schools and colleges. But, sooner or later, these subjects must be discussed on their intrinsic merits for the ends in view.

I shall occupy the present paper with the consideration of two departments in the examination programme—the one relating to the physical or natural sciences,[2] the other relating to languages.

This second topic is one of very serious import. It concerns the Civil Service competitions only as a part of our whole scheme of education. I mean the position of languages in our examinations. While the vast field of natural science is rolled up in one heading, with a total of 1,000 marks, our Civil Service scheme presents a row of five languages besides our own—two ancient and three modern—with an aggregate value of 2,625 marks. The India scheme has, in addition,

[1] From advance-sheets of a paper entitled "The Civil Service Examination Scheme considered with Reference—1. To Sciences; and, 2. To Languages," read at the recent meeting of the Social Science Congress in Aberdeen, Scotland.

[2] This part of the address is omitted for want of space.

Sanskrit and Arabic, at 500 marks each; the reasons of this prescription being, however, not the same as for the foregoing.

The place of language in education is not confined to the question as between the ancient and the modern languages. There is a wider inquiry as to the place of languages as a whole. In pursuing this inquiry, we may begin with certain things that are obvious and incontestable.

In the first place, it is apparent that if a man is sent to hold intercourse with the people of a foreign nation, he must be able to understand and to speak the language of that nation. Our India civil servants are, on that ground, required to master the Hindoo spoken dialects.

In the next place, if a certain range of information that you find indispensable is locked up in a foreign language, you are obliged to learn the language. If, in course of time, all this information is transferred to our native tongue, the necessity apparently ceases. These two extreme suppositions will be allowed at once. There may, however, be an indefinite number of intermediate stages: the information may be partially translated; and it will then be a question whether the trouble of learning the language should be incurred for the sake of the untranslated part. Or, it may be wholly translated; but viewing the necessary defects, even of good translations, if the subject-matter be supremely important, some people will think it worth while to learn the language in order to obtain the knowledge in its greatest purity and precisions. This is a situation that admits of no certain rule. Our clergy are expected to know the original languages of the Bible, notwithstanding the abundance of translations, many of which must be far superior in worth and authority to the judgment of a merely ordinary proficient in Hebrew and Greek.

It is now generally conceded that the classical languages are no longer the exclusive depository of any kind of valuable information, as they were two or three centuries ago; yet they are still continued in the schools as if they possessed their original function unabated. We do not speak in them, nor listen to them spoken, nor write in them, nor read in them, for obtaining information. Why, then, are they kept up? Many reasons are given, as you know. There is an endeavor to show that, even in their original function, they are not quite effete. Certain professions are said to rely upon them for some points of information not fully communicated by the medium of English. Such is the rather indirect example of the clergy with Greek. So it is said that law is not thoroughly understood without Latin, because the great source of law, the Roman code, is written in Latin, and is in many points untranslatable. Further, it is contended that Greek philosophy cannot be fully mastered without a knowledge of the language of Plato and Aristotle. But an argument that is reduced to these examples must be near its vanishing-point. Not one

of the cases stands a rigorous scrutiny, and they are not relied upon as the main justification of the continuance of classics. A new line of defense is opened up that was not at all present to the minds of sixteenth-century scholars. We are told of numerous indirect and secondary advantages of cultivating language in general and the classic languages in particular, which make the acquisition a rewarding labor, even without one particle of the primary use. But for these secondary advantages, languages could have no claim to appear, with such enormous values, in the Civil Service scheme.

My purpose requires me to advert to these alleged secondary uses of language—not, however, for the purpose of counter-arguing them, but rather to indicate what seems to me the true mode of bringing them to the proof.

The most usual phraseology for describing the indirect benefit of languages is that they supply a *training* to the powers of the mind; that, if not information, they are *culture;* that they react upon our mastery of our own language, and so on. It is quite necessary, however, to find terms more definite and tangible than the slippery words "culture" and "training;" we must know in precise language what particular powers or aptitudes are increased by the study of a foreign language. Nevertheless, the conclusions set forth in this paper do not require me to work out an exhaustive review of these advantages. It is enough to give as many as will serve for examples.

Now, it must be freely admitted, as a possible case, that a practice introduced, in the first instance, for a particular purpose, may be found applicable to many other purposes; so much so that, ceasing to be employed for the original use, this practice may be kept up for the sake of the after-uses. For example, clothing was no doubt primarily contrived for warmth; but it is not now confined to that—decoration or ornament, distinction of sexes, ranks, and offices, modesty—are also attained by means of clothes. This example is a suggestive one. We have only to suppose ourselves migrating to some African climate, where clothing for warmth is absolutely dispensed with. We should not on that account adopt literal nudity—we should still desire to maintain those other advantages. The artistic decoration of the person would continue to be thought of; and, as no amount of painting and tattooing, with strings of beads superadded, would answer to our ideal of personal elegance, we should have recourse to some light, filmy textures, that would allow the displays of drapery, colors, and design, and show off the poetry of motion; we should also indicate the personal differences that we were accustomed to show by vesture. But now comes the point of the moral: we should not maintain our close, heavy fabrics, our great-coats, shawls, and cloaks. These would cease with the need for them. Perhaps the first emigrants could keep up the prejudice for their warm things, but not so their successors.

Well, then, suppose the extreme case of a foreign language that is entirely and avowedly superseded as regards communication and interpretation of thoughts, but still furnishing so many valuable aids to mental improvement that we keep it up for the sake of these. As we are not to see, speak, or read the language, we do not need absolutely to know the meaning of every word; we may, perhaps, dispense with much of the technicality of its grammar. The vocables and the grammar would be kept up exactly so far as to serve the other purposes, and no further. The teacher would have in view the secondary uses alone. Supposing the language related to our own by derivation of words, and that this was what we put stress upon, then the derivation would always be uppermost in the teacher's thoughts. If it were to illustrate universal grammar and philology, this would be brought out to the neglect of translation.

I have made an imaginary supposition to prepare the way for the real case. The classical, or language, teacher is assumed to be fully conscious of the fact that the primary use of the languages is as good as defunct; and that he is continued in office because of certain clearly-assigned secondary uses, but for which he would be suspended entirely. Some of the secondary uses present to his mind, at all events one of those that are put forward in argument, is that a foreign language, and especially Latin, conduces to good composition in our own language. And as we do compose in our own language, and never compose in Latin, the teacher is bound to think mainly of the English part of the task: to see that the pupils succeed in the English translation, whether they succeed in the other or not. They may be left in a state of considerable ignorance of good Latin forms—ignorance will never expose them—but any defects in their English expression will be sure to be disclosed. Again, it is said that universal grammar or philology is taught upon the basis of a foreign language. Is this object, in point of fact, present to the mind of every teacher, and brought forward, even to the sacrifice of the power of reading and writing, which, by the supposition, is never to be wanted? Further, the Latin grammar is said to be a logical discipline. Is this, too, kept in view as a predominating end? Once more, it is declared that through the classics we attain the highest cultivation of taste, by seeing models of unparalleled literary form. Be it so; is this habitually attended to in the teaching of these languages?

I believe I am safe in saying that, while these various secondary advantages are put forward in the polemic as to the value of languages, the teaching practice is not in full consistency therewith. Even when in word the supporters of classics put forward the secondary uses, in deed they belie themselves. Excellence in teaching is held by them to consist, in the first instance, in the power of accurate interpretation, as if that obsolete use were still *the* use. If a teacher does this well, he is reckoned a good teacher, although he

does little or nothing for the other ends, which, in argument, are treated as the reason of his existence. Indeed, this is the kind of teaching that is alone to be expected from the ordinary teacher; all the other ends are more difficult than simple word-teaching. Even when English composition, logic, and taste, are taught in the most direct way, they are more difficult than the simple teaching of a foreign language for purposes of interpretation; but when tacked on as accessories to instruction in a language, they are still more troublesome to impart. A teacher of rare excellence may help his pupils in English style, in philology, in logic, and in taste; but the mass of teachers can do very little in any of those directions. They are never found fault with merely because their teaching does not rise to the height of the great arguments that justify their vocation; they would be found fault with if their pupils were supposed to have made little way in that first function of language which is never to be called into exercise.

I do not rest satisfied with quoting the palpable inconsistency between the practice of the teacher and the polemic of the defender of languages. I believe, further, that it is not expedient to carry on so many different acquisitions together. If you want to teach thorough English you need to arrange a course of English, allot a definite time to it, and follow it with undivided attention during that time. If you wish to teach philology, provide a systematic scheme, or text-book of philology, and bring together all the most select illustrations from languages generally. So for logic and for taste: these subjects are far too serious to be imparted in passing allusions while the pupil is engaged in struggling with enigmatic difficulties. They need a place in the programme to themselves; and, when so provided for, the small dropping contributions of the language-teacher may easily be dispensed with.

The argument for languages may, no doubt, take a bolder flight, and maintain that the teacher does not need to turn aside from his plain path to secure these secondary ends—now the only valuable ends. The contention may be that in the close and rigorous attention to mere interpretation, just as if interpretation were still the living use, these other purposes are inevitably secured—good English, universal grammar, logic, taste, etc. I think, however, that is too far from the fact to be very confidently maintained. Of course, were it correct, the teacher should never have departed from it, as the best teachers continually do, and glory in doing.

On the face of the thing, it must seem an unworkable position to surrender the value of a language, as a language, and keep it up for something else. The teaching must always be guided by the original, although defunct, use. This is the natural, the easy course to follow; for the mass of teachers at all times it is the broad way. Whatever the necessities of argument may drive a man to say, yet in his teach-

ing he cannot help postulating to himself, as an indispensable fiction, that his pupils are some day or other to hear, to read, to speak, or to write, the language.

The intense conservatism in the matter of languages, the alacrity to prescribe languages on all sides, without inquiring whether they are likely to be turned to account, may be referred to various causes. For one thing, the remark may seem ungracious and invidious that many minds, not always of the highest force, are absorbed and intoxicated by languages. But apart from this they are, by comparison, easy to teach and easy to examine upon. Now, if there is any motive in education more powerful than another, it is ease in the work itself. We are all, without exception, copyists of that Irish celebrity who, when he came to a good bit of road, paced it to and fro a number of times before going forward on the rougher footing.

So far I may seem to be arguing against the teaching of language at all, or, at any rate, the languages expressively called dead. I am not, however, pressing this point further than as an illustration. I do not ask any one to give an opinion against classics as a subject of instruction; although, undoubtedly, if this opinion were prevalent, my principal task would be very much lightened. I have merely analyzed the utilities ascribed to the ancient and modern languages, with a view to settling their place in competitive examinations.

My thesis, then, is that languages are not a proper subject for competition with a view to professional appointments. The explanation falls under two heads:

In the first place, there are certain avocations where a foreign language must be known, because it has to be used in actual business. Such are the Indian spoken languages. Now, it is clear that in such cases the knowledge of the language, as being a *sine qua non*, must be made imperative. This, however, as I think, is not a case for competition, but for a sufficient pass. There is a certain pitch of attainment that is desirable even at first entering the service; no one should fall below this, and to rise much above it cannot matter a great deal. At all events, I think the measure should be absolute and not relative. I would not give a man merit in a competition because another man happens to be worse than himself in a matter that all must know; both the men may be absolutely bad.

It may be the case that certain languages are so admirably constructed and so full of beauties that to study them is a liberal education in itself. But this does not necessarily hold of every language that an official of the British Empire may happen to need. It does not apply to the Indian tongues, nor to Chinese, nor, I should suppose, to the Feejee dialects. The only human faculty that is tested and brought into play in these acquisitions is the commonest kind of memory exercised for a certain time. The value to the service of the man that can excel in spoken languages does not lie in his superior admin-

istrative ability, but in his being sooner fitted for actual duty. Undoubtedly, if two men go out to Calcutta so unequal in their knowledge of native languages, or in the preparation for that knowledge, that one can begin work in six months, while the other takes nine, there is an important difference between them. But what is the obvious mode of rewarding the differences? Not, I should think, by pronouncing one a higher man in the scale of the competition, but by giving him some money-prize in proportion to the redemption of his time for official work.

Now, as regards the second kind of languages, those that are supposed to carry with them all the valuable indirect consequences that we have just reviewed. There are in the Civil Service scheme five such languages—the two ancient, and three modern. They are kept there, not because they are ever to be read or spoken in the service, but because they exercise some magical efficacy in elevating the whole tone of the human intellect.

If I were discussing the Indian Civil Service in its own specialties, I would deprecate the introduction of extraneous languages into the competition for this reason, that the service itself taxes the verbal powers more than any other service. I do not think that Lord Macaulay and his colleagues had this circumstance fully in view. Macaulay was himself a glutton for language; and, while in India, read a great quantity of Latin and Greek. But he was exempted from the ordinary lot of the Indian civil servant; he had no native languages to acquire and to use. If a man both speaks and writes in good English, and converses familiarly in several Oriental dialects, his language-memory is sufficiently well taxed, and if he carries with him one European language besides, it is as much as belongs to the fitness of things in that department.

My proposal, then, goes the length of excluding all these five cultivated languages from the competition, notwithstanding the influence that they may be supposed to have as general culture. In supporting it, I shall assume that everything that can be said in their favor is true to the letter; that they assist us in our language, that they cultivate logic and taste, that they exemplify universal grammar, and so on. All that my purpose requires is to affirm that the same good ends may be attained in other ways; that Latin, Greek, etc., are but one of several instruments for instructing us in English composition, reasoning, taste, and so on. My contention, then, is that the ends themselves are to be looked to, and not the means or instruments, since these are very various. English composition is, of course, a valuable end, whether got through the study of Latin, or through the study of English authors themselves, or through the inspiration of natural genius. Whatever amount of skill and attainment a candidate can show in this department should be valued in the examination for English; and all the good that Latin has done for him would

thus be entered to his credit. If, then, the study of Latin is found the best means of securing good marks in English, it will be pursued on that account; if the candidate is able to discover other less laborious ways of attaining the end, he will prefer these ways.

The same applies to all the other secondary ends of language. Let them be valued in their own departments. Let the improvement of the reasoning faculty be counted wherever that is shown in the examination. Good reasoning powers will evince themselves in many places, and will have their reward.

The principle is a plain and obvious one. It is the payment for results, without inquiring into the means. There are certain extreme cases where the means are not improperly coupled with the results in the final examination; and these are illustrations of the principle. Thus, in passing a candidate for the medical profession, the final end is his or her knowledge of diseases and their remedies. As it is admitted, however, that there are certain indispensable preparatory studies—anatomy, physiology, and materia medica—such studies are made part of the examination, because they contribute to the testing for the final end.

The argument is not complete until we survey another branch of the subject of examination in languages. It will be observed in the wording of the programme that each separate language is coupled with "literature and history." It is the language, literature, and history, of Rome, Greece, etc. And the examination-questions show the exact scope of these adjuncts, and also the values attached to them, as compared with the language by itself.

Let us consider this matter a little. Take history first, as being the least involved. Greece and Rome have both a certain lasting importance attaching to their history and institutions; and these, accordingly, are a useful study. Of course, the extant writings are the chief groundwork of our knowledge of these, and must be read. But at the present day all that can be extracted from the originals is presented to the student in English books; and to these he is exclusively referred for this part of his knowledge. In the small portion of original texts that a pupil at school or college toils through, he necessarily gets a few of the historical facts at first hand, but he could much more easily get these few where he gets the rest, in the English compilations. Admitting, then, that the history and institutions of Greece and Rome constitute a valuable education, it is in our power to secure it independently of the original tongues.

The other branch—literature—is not so easily disposed of. In fact, the separating of the literature from the language, you will say, is a self-evident absurdity. That, however, only shows that you have not looked carefully into examination-papers. I am not concerned with what the *a priori* imagination may suppose to be literature, but with the actual questions put by examiners under that name. I find

that such questions are, generally speaking, very few, perhaps one or two in a long paper, and nearly all pertain to the outworks of literature, so to speak. Here is the Latin literature of one paper: In what special branch of literature were the Romans independent of the Greeks? Mention the principal writers in it, with the peculiar characteristics of each. Who was the first to employ the hexameter in Latin poetry, and in what poem? To what language is Latin most nearly related, and what is the cause of their great resemblance? The Greek literature of the same examination involves these points: The Aristophanic estimate of Euripides, with criticisms on its taste and justice (for which, however, an historical subject is given as an alternative); the Greek chorus, and choric metres. Now, such an examination is, in the first place, a most meagre view of literature: it does not necessarily exercise the faculty of critical discernment. In the next place, it is chiefly a matter of compilation from English sources; the actual readings of the candidate in Greek and Latin would be of little account in the matter. Of course, the choric metres could not be described without some knowledge of Greek, but the matter is of very trifling importance in an educational point of view. Generally speaking, the questions in literature, which in number bear no proportion to historical questions, are such as might be included under history, as the department of the history of literature.

The distribution of the 750 marks allotted respectively to Latin and to Greek, in the present scheme, is this: There are three papers—two are occupied exclusively with translation. The third is language, literature, and history: the language means purely grammatical questions; so that 583 marks are given for the language proper. The remaining number, 167, should be allotted equally between literature and history; but history has always the lion's share, and is, in fact, the only part of the whole examination that has, to my mind, any real worth. It is generally a very searching view of important institutions and events, together with what may be called their philosophy. Now, the reform that seems to me to be wanted is to strike out everything else from the examination. At the same time, I should like to see the experiment of a real literary examination, such as did not necessarily imply a knowledge of the originals.

It is interesting to turn to the examination in modern languages, where the ancient scheme is copied, by appending literature and history. Here the literature is decidedly more prominent and thorough. There is also a fair paper of history questions. What strikes us, however, in this, is a slavish adherence to the form, without the reality, of the ancient situation. We have independent histories of Greece and Rome, but scarcely of Germany, France, and Italy. Instead of partitioning modern European history among the language-examiners for English, French, German, Italian, it would be better to relieve them of history altogether, and place the subject as a whole in the

hands of a distinct examiner. I would still allow merit for a literary examination in French, German, and Italian, but would strike off the languages, and let the candidate get up the literature as he chose. The basis of a candidate's literary knowledge, and his first introduction to literature, ought to be his own language; but he may extend his discrimination and his power by other literatures, either in translations or in originals, as he pleases; but the examination, as before, should test the discrimination and the power, and not the vocabulary, of the languages themselves.

In order to do full justice to classical antiquity, I would allow the present markings to continue, at the rate of 500 for political institutions and history, and 250 for literature. Some day this will be thought too much; but political philosophy or sociology may become more systematic than at present, and history questions will then take a different form.

In like manner, I would abolish the language-examination in modern languages, and give 250 marks for the literature of each of the three modern languages—French, German, Italian. The history would be taken as modern history, with an adequate total value.

The objections to this proposal will mainly revolve themselves into its revolutionary character. The remark will at once be made that the classical languages would cease to be taught, and even the modern languages discouraged. The meaning of this I take to be, that, if such teaching is judged solely by its fruits, it must necessarily be condemned.

The only way to fence this unpalatable conclusion is to maintain that the results could not be fully tested in an examination as suggested. Some of these are so fine, impalpable, and spiritual in their texture, that they cannot be seized by any questions that can be put, and would be dropped out if the present system were changed. But results so untraceable cannot be proved to exist at all.

So far from the results being missed by disusing the exercises of translation, one might contend that they would only begin to be appreciated fairly when the whole stress of the examination is put upon them. If an examiner sets a paper in Roman law, containing long Latin extracts to be translated, he is starving the examination in law by substituting for it an examination in Latin. Whatever knowledge of Latin terminology is necessary to the knowledge of law should be required, and no more. So, it is not an examination in Aristotle to require long translations from the Greek; only by dispensing with all this does the main subject receive proper attention.

If the properly literary part of the present examinations were much of a reality, there would be a nice discussion as to the amount of literary tact that could be imparted in connection with a foreign language, as translated or translatable. But I have made an ample concession, when I propose that the trial should be made of examin-

ing in literature in this fashion; and I do not see any difficulty beyond the initial repugnance of the professors of languages to be employed in this task, and the fear, on the part of candidates, that undue stress might be placed on points that need a knowledge of originals.

I will conclude with a remark on the apparent tendency of the wide options in the commissioners' scheme. No one subject is obligatory; and the choice is so wide that by a very narrow range of acquirements a man may sometimes succeed. No doubt, as a rule, it requires a considerable mixture of subjects: both sciences and literature have to be included. But I find the case of a man entering the India service by force of languages alone, which I cannot but think a miscarriage. Then the very high marks assigned to mathematics allow a man to win with no other science, and no other culture, but a middling examination in English. To those that think so highly of foreign languages, this must seem a much greater anomaly than it does to me. I would prefer, however, that such a candidate had traversed a wider field of science, instead of excelling in high mathematics alone.

There are, I should say, three great regions of study that should be fairly represented by every successful candidate. The first is the sciences as a whole, in the form and order that I have suggested. The second is English composition, in which successful men in the India competition sometimes show a cipher. The third is what I may call loosely the humanities, meaning the department of institutions and history, with perhaps literature: to be computed in any of the regions of ancient and modern history. In every one of these three departments I would fix a minimum below which the candidate must not fall.

ON THE COMPARATIVE STUPIDITY OF POLITICIANS.[1]

WE owe an apology to a very respectable class of persons for the apparent, but we trust only apparent, and certainly involuntary, discourtesy of the thesis to which we invite attention. The late Mr. Mill, in a well-known passage, called the Conservatives the stupid party. We do not call them so, nor their opponents. All we venture to assert of both is, that in a universe of graduated intelligence they are not highest in the scale. The great majority of even prominent politicians have just the gifts which make a man conspicuous in a town-council or a board of guardians: physical energy, moral persistency, and ideas on a level with those of their fellows. Miss Martineau, in her very candid "Autobiography," has recorded her sense of the mental and moral inferiority of the political men with

[1] Condensed from *Fraser's Magazine*.

whom, during her period of lionizing in London, she was brought into contact, as compared with the men of letters, and still more with the men of science, whose acquaintance she made. She observed in the politicians a much lower type of mind and character, expressing itself even in a certain vulgarity of manners, the lowest point being reached in all these particulars by the Whig aristocracy of the day.

In the long prevalence of an aristocratic monopoly, diminished now, but not altogether done away with, and subsisting still in its effects even more powerfully than in itself, one of the special causes of the comparative stupidity of politicians in England may be discerned. But the evil is inherent in the very conditions of what are called practical politics. The real development of mind is to be sought in what Mr. Arnold calls its disinterested play in science and art. Discipline in the methods of research after truth, familiarity with the highest conceptions of the universe, delight in the most perfect forms of expression, whether they take the shape of literature or of the plastic and imitative arts, these are the feeders and purifiers of the mind. The artist, including the author as well as the sculptor, the painter, and the actor, and the man of science, live, so far as they are true to their work, in the society of Nature and of its great interpreters. They are constantly in the presence of their betters. The statesman lives habitually in the society of county and borough members; or, if we restrict our view to the intimate associations of the cabinet, of men little, if at all, above these intellectually. In other words, the finest mind is habitually in the presence of its inferiors, whose ideas and impulses are to it what his daily beer was to Mr. Justice Maule, the instrumentality with which he brought himself down to the level of his work. He must think their thoughts and speak their language. To be over their heads, to be, as a dexterous politician said of a great philosopher, too clever for the House of Commons, to have nobler and farther-reaching conceptions than they, is to commit the sin for which there is no parliamentary forgiveness. It is sometimes said that the House of Commons is wiser than any single member; a saying which, according as it is interpreted, is either an absurdity or a truism. It may mean, what is indisputable, that the whole is greater than the part, or, what is impossible, that the average is higher than the elements which raise it. The House of Commons can only be wiser than some particular member by following the guidance of some other member who, on that particular occasion, is wiser than he; that is to say, it is wiser than one of its less wise members. The saying, however, is intended to affirm the position that intellectual superiority is not the truest guide in politics, or, in other words, that politicians, in so far as they are successful, are comparatively stupid, a position which we are far from disputing. On the contrary, we affirm it as a truth of observation and experience, and are at the present moment doing our best to ac-

count for it. As regards the proposition itself, it means simply that the House of Commons knows its own mind, such as it is, and, whatever the worth of that knowledge, better than any single member of it; and as a rule the average member who is in sympathy with it will interpret it better than the member of much higher powers who is above its level. But it is only wiser than its wisest members in the sense in which the field may be said to be wiser than the farmer, or the ocean than the navigator; that is to say, in no intelligible sense at all. Like Nature, if it is to be commanded it must be obeyed, and the necessity of understanding it is, by confusion of thought, taken for its understanding of itself.

The inferior society in which politicians live, inferior in intelligence and cultivation, and the necessity of adapting their own thoughts and aims to those of the ordinary minds and characters they have to influence, brings about the decline and deterioration of men of originally fine endowments. It either prevents these qualities from developing, or stunts them where they have a certain degree of growth. Their "nature is subdued to what it works in, like the dyer's hand." This evil is in part qualified by another. It is chiefly the second-rate order of minds and characters that betake themselves now to politics in England—minds already on the level to which superiority needs to be reduced before it can be effective. For this reason, probably, whenever an occasion demands a hero in politics, he has been seldom found in the walks of professional statesmanship. The national crisis which asks for a deliverer finds him not among those who have been deteriorated and dwarfed by the ordinary work and associations of politics, but in a man who has lived among nobler ideas and associations, and cultivated a larger and more liberal nature. The practice of affairs is, no doubt, a discipline of some value; but nearly everything depends on what the affairs are. To manage the House of Commons, to get bills through committee, to administer a public office, does not seem usually to be good training for very difficult business. When a considerable emergency occurs there is almost invariably a breakdown of the departments. The true discipline of public business is to teach men readiness in action and fertility in resources. Its ordinary effect is to harden them in routine, which suits poorly enough even the common round and the daily task of business, and which is a hinderance, and which may be ruin when necessities, transcending precedents and rules of office, have to be encountered. The fact is, that the training of affairs, invaluable as it is, seldom bears its proper fruit, unless the affairs are a man's own, or when the consequences of failure are sure to come upon him in a rapid and crushing manner. The merchant or capitalist, whose ventures depend upon his personal vigilance; the engineer, who has to deal with overwhelming physical forces; the military commander, who has to contend at once with the not always benevolent neutral-

ity of Nature and the watchfulness of human enemies, cannot afford to take things easily. Action is forced upon them; they must either succeed or conspicuously fail. In politics, usually, the state of things is entirely different. The demand is rarely made for heroic measures; the prudence which is taught is that rather which shuns difficulty and dreads failure, than that blending of caution and audacity which finds in the way of seeming danger the true path of safety. The education of practice in parliamentary politics is, therefore, for the most part, an education in the arts of inaction, evasion, and delay. The blame of doing nothing is usually less than the blame of doing amiss. A great writer, whose instinctive sagacity was often wiser than the elaborated reflections of more painful thinkers, embodied the characteristic weakness of political training in England when he made "How not to do it" the aim of our statesmen. Lord Melbourne's "Can't you leave it alone?" gave expression to the same paralysis of action in excessive caution and prudence. Politics of this sort will attract feeble minds and characters, or will enfeeble those naturally stronger. The oratory which they foster will be that of mystification, amusement, and excitement. Acquaintance with political philosophy or economic science will be felt to be wholly superfluous. Even that empirical knowledge of his age and country, and of the assembly in and through which he rules, which are essential to every practical statesman, will be little more than the charlatan's or demagogue's acquaintance with the foibles and passions of popular sentiment and opinion. The admiral who boasted that he brought his ships home uninjured from seas in which he had not encountered the enemy, and the Frenchman whose achievement it was to have kept himself alive during the French Revolution, represent the prevalent aims of modern statesmanship. A ministry exists to keep itself in existence; if the ship, without going anywhere or doing anything, can be kept afloat, that is held to be all that can be required. This *fainéant* policy does not require any high range of intellect. Men of the first order will seek careers which afford ampler scope to capacity. If they betake themselves to public life, which affords them no opportunity of great public work, there is danger of their devoting their energies to their own private and personal ends; or, merely to establish a character for "honesty" will often prove enough to repose on. A picture, a statue, or a poem, does not receive additional value from the fact that its author is a very pleasant and straightforward sort of fellow; but "honest Jack Althorp's" statesmanship rested entirely on this basis of character; and a late parliamentary leader has been commended on the ground that "there is not the making of a lie in him." A career in which character may be a substitute for capacity must, from the nature of the case, be pursued on a lower intellectual level than those in which intelligence and cultivation and general or special knowledge are absolutely essential.

The natural and almost necessary inferiority of politicians as a class is compatible with the unsurpassed intellectual and moral greatness of statesmanship of the highest class. Men are not wanting in the history of any country, least of all in that of ours, and they have representatives among us now, who have found or made work for themselves to do which taxes the very highest gifts, and in the doing of which the very humblest and most commonplace allies and instruments acquire a sort of transfiguration. Their appearance and exertions mark the high-water point in the national life, an epoch of brief but fruitful work, an epoch of civil heroism. But the languor comes after the exertion; and in such a period of languor we seem now to be plunged. Even the men who counted for much when they followed a great leader become mere ciphers when the figure which stood at their head is removed.

Apart from these singular cases of moral and intellectual ascendency, the gifts which make a parliamentary leader are just those which make a man popular in society. The cheerful animal spirits and vigorous gayety of temperament which characterized Lord Palmerston, or the amusing qualities of a public entertainer which marked Charles Townshend (not to seek for living illustrations), are what it most relishes—the qualities which make a first-rate host in a country-house, or an amusing diner-out in town.

THE LARYNGOSCOPE AND RHINOSCOPE.

HOW THE AIR-PASSAGES ARE EXPLORED.

By F. SEEGER, M. D.

FROM the above names, most persons of average culture would at once infer that they are instruments for exploring the larynx and nose, and yet but few would suspect what simple little instruments they are—merely bits of looking-glass set in a frame and attached to a handle. But, when they give the matter a little further investigation, they are surprised at the greatness of the benefits which have already been reaped by mankind from the discovery of these self-same little instruments. They will learn that only a few years ago physicians were absolutely in the dark when applied to by those afflicted with disease of the throat; and that where then all was darkness, there now is clear light, thanks to the zeal and scientific devotion of Prof. Türck, of the University of Vienna, who in 1857 was the first to successfully use the laryngoscope as a means of determining the nature of a disease in the throat of a patient then in the

wards of the General Hospital of Vienna, of which latter Türck was the physician-in-chief. Justice and the truth of history, however, require that we should not omit mentioning the experiments and efforts of Senn, of Geneva (1827); Babington, of London (1829); Belloc, of Paris (1837); Baumes, of Lyons (1838); Liston, of London (1840); of Warden (1844); and, finally, of Manuel Garcia, a singing-teacher, of London. With the exception of the last, all of the experimenters had been disappointed in their efforts to devise an instrument sufficiently suitable and generally practical. Their experiments all lacked *that essential practical element* which made the subsequent labors of Türck and Czermak the solid basis for the grand superstructure which has grown up since their time. While Prof. Türck at Vienna, and Prof. Czermak, of the University of Krakau, the latter having become interested by Prof. Türck in the experiments, were thus developing the practical application of the laryngeal mirror (*Kehlkopffragenspiegel*, as Türck named it), Garcia, the now justly famous Spanish tenor and singing *maestro*, and father of the gifted songstress, Malibran, was at the very same time experimenting in London, but with totally different purposes. The object which Türck and Czermak had in view was to make the laryngoscope available as an adjunct and aid to the art and practice of medicine, or, in other words, as a means of diagnosis in disease of the throat. Garcia, on the other hand, was prompted by a desire to observe the actions of the vocal cords and larynx when producing tones and sounds. His observations were published in the *Royal Philosophical Magazine and Journal of Science* (vol. x., 1855), and they constitute the first physiological records of the human voice as based upon observations in the living subject. It is interesting at this date to turn to his remarks and to note the thoroughness therein displayed. The curious may refer to Madame Seiler's "The Voice in Singing," or to the writer's translation of Sieber's "Art of Singing." It is but proper to add that although Türck and Garcia were thus experimenting at one and the same time, neither, however, knew of the other nor of his efforts. Garcia accomplished his aim by standing with his back to the sun and catching its rays upon a looking-glass held in his left hand, which he then reflected into his opened mouth. Next he carried a dentist's mirror to the back of his mouth; and the sun's light which, in the first instance, was reflected from the mirror in the hand, being in turn reflected upon the dentist's mirror, served to illuminate the larynx below, and thus caused its picture to become visible in the dentist's mirror. Türck also used the sun's rays, but in a more direct manner, viz., without previous reflection. Prof. Czermak, as already remarked, soon became interested in Türck's experiments, and, borrowing some of Türck's mirrors, repeated the experiments. His labors resulted in a yet further and most brilliant development of the subject, by his introduction of a powerful artificial light, thus making us independent

of sunlight, and enabling an examination to be made at any time of the day or night.

For the clearer comprehension of the reader, I here introduce cut No. 1, which depicts the laryngoscope, or laryngeal mirror. At the left end we see the mirror, which is set in a silver frame and back; this in turn is attached to a metal stem, and the stem itself is set in a wooden handle, which latter is merely a matter of convenience by which the physician is enabled to handle it with more ease and facil-

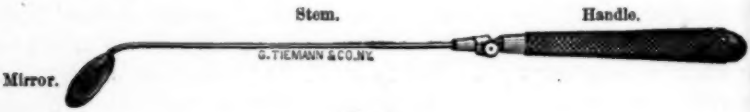


Fig. 1.

ity. The mirror is made of various sizes, from that of a cent to that of a silver half-dollar, and is so attached to the stem as to describe an angle of 120° to 125°.

Prior to the discovery of the laryngoscope, the great obstacle to the diagnosis and comprehension of disease of the larynx lay in the fact that this organ was so placed as to be at an almost direct angle to the line of vision. If we look into the mouth of another person, we see the back of the mouth; but if we wish to see the larynx, or organ of tone and voice, we are unable to do it, even though its position is just back of and below the root of the tongue. And, even though we press down the tongue, we derive no aid. Nor are we enlightened by symptoms of pain or discomfort in the throat, for these are not only insufficient, but may be absolutely deceptive. A patient may complain of aches and pains, and may imagine them in the larynx, and all the while the organ be in a perfectly sound state; and, on the other hand again, grave forms of throat-disease may exist, and with so little of actual pain as to cause the victim hardly any uneasiness. The revolution in this department of the medical art may perhaps be best illustrated when I refer to the fact that ere the introduction of the laryngeal mirror, barely twenty years ago, there were but two or three forms of laryngeal disease recognized or treated of in the text-books on the practice of medicine. At the present time, the study of the numerous and varied diseases of this wonderful little organ, the larynx, has made such strides that laryngology has, like ophthalmology, otology, and gynæcology, demanded and received recognition as a separate and distinct department of medical practice, and has its special practitioners in almost every city of size and population. Whereas, formerly, the two or three recognized forms of throat-disease were dismissed in a scant dozen of pages in the medical text-works, we now have exhaustive and elaborate treatises in all of the great languages of the civilized world. Twenty

years ago inflammation, laryngeal phthisis, or, popularly speaking, throat-consumption, and œdema, constituted the three recognized forms of throat-affection; but, in eight years from the first practical application of this instrument, the revolution was such that separate treatises described and treated of forty and more varieties of disease, such as acute laryngitis and the various acute affections; simple chronic laryngitis, chronic ulcerative laryngitis; of six or seven forms of inflammation of special parts of the larynx; of tubercular and syphilitic laryngitis, œdema, abscess, etc. Next we find descriptions of the diseases which attack the laryngeal cartilages or framework of the larynx, as perichondritis and chondritis. Then follow nervous forms of derangement, and then paralytic forms of difficulty. In the first we have conditions of nervous exaltation, such as spasmodic coughs, spasms, etc. Under the second head we have paralytic affections of the vocal cords and laryngeal muscles. These paralytic difficulties of the larynx may exist in the larynx without much or even any impairment of the general health. Then we have anæmia or impoverished blood-supply, and finally the varied forms of tumors and morbid growths, cancerous, syphilitic, etc. I might prolong this list yet further, and even dwell at length upon the many and ingenious instruments for operating within the larynx, but to do so would be to exceed the limits of my article.

The rhinoscopic mirror, or rhinoscope, is practically but a laryngeal mirror of a smaller size. The stem and handle are the same, and attached in the same manner, at about the same angle, but there is the difference of a much smaller size as compared to the laryngoscope, the mirror being usually about the size of a silver three-cent piece. Its use is to enable us to see the back or inner parts of the nose (posterior nares), and the upper part of the pharynx or vault of the back of the mouth. Its discovery, which occurred soon after that of the laryngoscope, is due to the patience and genius of Czermak, and was a direct result of the discovery of the laryngeal mirror. The parts which it enables us to see are hidden behind and above the palate, and the office of the rhinoscopic mirror is simply to so reflect the light as to illuminate these parts, and in turn enable their image to become visible in the mirror. In the first instance the little mirror is placed at the back of the opened mouth of the patient. At the same time a powerful and clear light from an illuminating apparatus is directed into the patient's mouth, and the rays striking upon the mirror are so reflected upward and forward as to illuminate the parts we seek to examine, and these are then, as just remarked, made visible in the mirror. And in this principle lies the entire secret of the art of making a laryngoscopic or rhinoscopic examination. It is simply a dexterous management of mirrors to secure proper reflection of light, and the consequent illumination and examination of hidden recesses.

The rhinoscope also enables us to examine the nasal or pharyngeal orifices of the Eustachian tubes. These latter are passages leading from the inner side of the drum of the ear, and opening, as already indicated, at a point situated in the posterior nasal parts. It is not the province of this article to enter into minute or precise detail, and therefore we shall merely add that these tubes bear a very important relation to the faculty of hearing. If the nasal orifices of these tubes become swollen by disease, or choked with diseased mucus, greater or less impairment of the hearing-power results. Consequently, the rhinoscope has rendered no small service to us for determining causes of deafness, and of curing them, which formerly were but guessed at or remained unknown.

But to make the laryngeal and rhinal mirrors available, the artificial illumination of these parts is necessary. To depend upon the sun's rays, as was the case with the original experiments, was too uncertain. Czermak, as we have seen, substituted artificial light, and thus enabled an examination to be made at any hour of the day or night. Tobold, of Berlin, after a time, brought forward an apparatus which is depicted in the following cut, and which embodied the most perfect apparatus of the time. The cut also shows us the position of the patient and of the examiner.

As introduced by him, it consisted of a common study-lamp: *a*

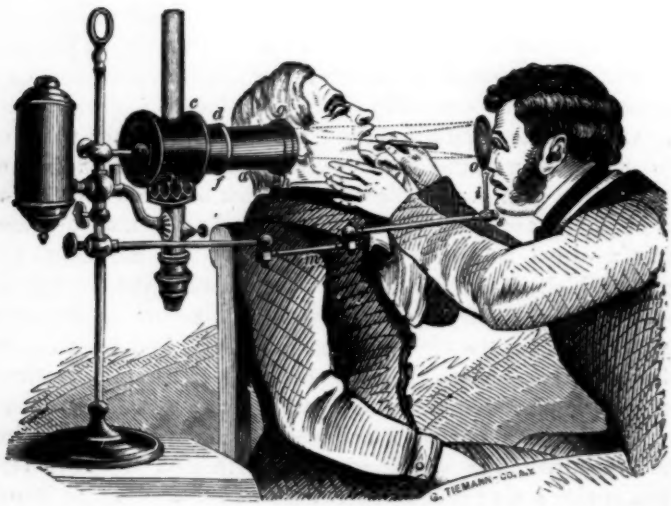


FIG. 2.

is a brass tube, or light-condenser, in which are convex lenses, *c*, *d*, *g*. The lenses *c* and *d*, it will be observed, are close together, while the third, *g*, is at the distal extremity of this brass tube. At *f* this brass tube can be unscrewed, thus enabling the cleansing of the lenses.

The lens *g* can also be removed at *h*. *m* is a brass arm having three joints, and fastened to the lamp. At the extremity of this arm is a perforated knob, *s*, through which the handle of the reflector, *i*, is passed, and which is fastened by a screw. At *o* is a single *charnière* joint, which permits of the forward or backward motion of the reflector—the illuminating agent being oil. By substituting gas burned through an Argand burner, and fed from any ordinary burner, the apparatus has been made more available, and better light obtained. The following cut represents the improved apparatus as now made.

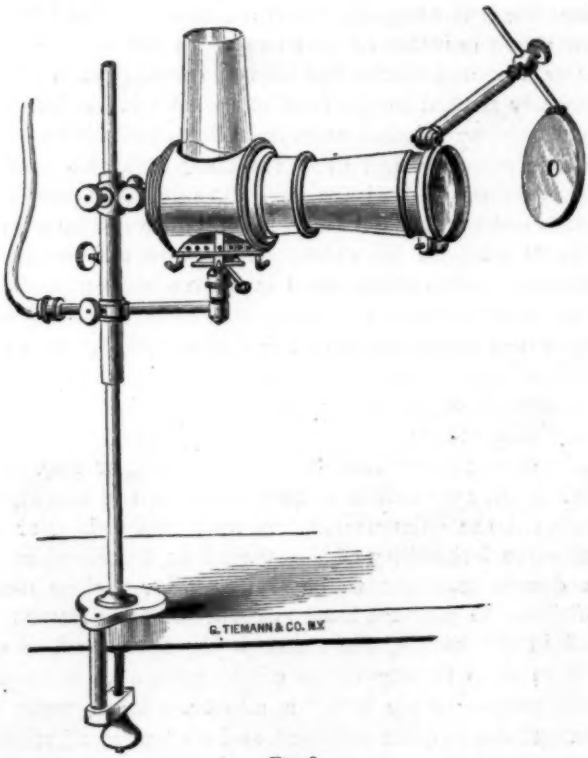


FIG. 8.

It is not necessary to dwell upon the changes. Suffice it that by these the apparatus has been made much more ready and simple in management, and less liable to derangement of focus at important moments when a steady light is needed for intra-laryngeal operations. It is here that we should call a brief attention to the vast strides which, under the influence of the laryngoscope, have been effected in the operative procedures upon this organ. All of these are now made by means of instruments curved at a direct angle to the line of vision, and in none of these operations does the operator directly see the

objective point. His operations are all made under the guidance of the image which he sees reflected in the laryngeal mirror, and are comparatively bloodless and accompanied by little or no pain.

A laryngoscopic examination is made as follows: In the second cut we see the positions of the examiner and patient. The patient opens his mouth as widely as possible, and at the same time protrudes his tongue. The examiner, then, with a small napkin takes the protruded tongue between his thumb and forefinger, thus gently steadying it and preventing its slipping back into the mouth. The object in thus protruding the tongue is to enlarge the cavity of the mouth as much as possible. The laryngeal mirror is next warmed either over the chimney of the illuminator or in some warm water, so as to prevent its becoming obscured or dimmed by the breath. It is then quickly and dexterously carried to the back of the mouth. A bungling manner of doing this, by causing great irritation of sensitive parts of the mouth, causes gagging and even vomiting, and, this once excited, all further examination is either very difficult or impossible at this sitting. It is not to be taken for granted, however, that examinations can readily be made in all cases, nor even in the larger majority of the patients. With many there is no trouble, but there are also quite a number of patients whose throats are so irritable from disease as to prevent the introduction of the laryngoscope. In other cases the patient's tongue has an almost irresistible tendency to keep rising up toward the roof of the mouth and thus obstruct the view. Enlargement of the tonsils according to the degree of their enlargement makes an examination either very difficult, or else, if so much enlarged that they meet and almost close up the throat, makes it impossible until the enlargement has been reduced. For the overcoming of mere irritability of the throat or fauces when this pertains to a degree sufficient to be troublesome, various means have been resorted to, to produce local anæsthesia of the fauces. A piece of ice held in the mouth, the water being swallowed, is one plan. Another is to drop twenty drops of chloroform on a handkerchief and let the patient inhale it for a minute. With most cases of irritable throat this is quite sufficient, and without at all rendering the patient drowsy or uncomfortable. Bromide of potash has been used, but has not given satisfaction practically.

The examiner, having avoided touching the back of the tongue and of the pharynx with the mirror, carries it, as already said, to the back of the mouth to an oblique position below the soft palate and with the uvula or "drop" of the palate at its back. The rays of light from the illuminating apparatus, striking the laryngeal mirror, are then reflected in a downward direction and light up the parts (the larynx) below. These, being illuminated, are in return depicted upon the laryngeal mirror above. The process may be compared to that of the management of toilet-mirrors to enable us to see the back

of the head. In the latter proceeding it is not the back of the head which we see, but, as is hardly necessary to add, merely its reflection in the mirror.

And at this point we should remark that, while the laryngeal examination to one versed in the art is comparatively easy, the rhinoscopic examination, on the other hand, is a very difficult matter, and calls into play no small amount of skill and ingenuity. The reasons for this are mainly because of the unruliness of most palates, which have a tendency to bob up and down in a very provoking manner. We shall not dwell further upon this point, but briefly add a few remarks as to what this instrument has done for us. Where we can apply it we are no longer in the dark as to whether a case of disease is that of a chronic catarrh, nasal tumor, simple inflammation, swelling, or ulceration. In our climate, in which diseases of the nasal cavities, and particularly catarrh, are so prevalent that it has been estimated that 10,000,000 of our people have the disease called catarrh to a greater or less degree, every advance by which we are enabled the more successfully to combat these complaints is of general interest and importance. How potent our climate is in causing catarrh is illustrated in the case of Charles Dickens, who contracted it so rapidly and severely as to necessitate his abandoning many engagements and compel his flight from this country. Interesting is the fact, which Darwin records in his "Descent of Man," that the *Cebus azaræ*, a species of Paraguayan monkey, is liable to catarrh with all of the symptoms found in his more human relatives, and which when often recurrent leads in them to consumption.

The higher animals, like man, are endowed with an organ of voice and sound, but man alone has the supreme gift and faculty of expressing the ideas and thoughts which his intellectual endowments and powers give rise to, or, plainly speaking, he alone has an articulate language equal to the expression of most of his feelings and sentiments. How wonderful, then, it becomes to us when we study the little organ which has the great task of placing man in direct communication with his fellow-beings! And how wonderfully this little organ modulates its tones in accordance with the varying degrees of emotion and earnestness! And when we consider that each voice has its own peculiarities and characteristics which distinguish it from all others, our interest deepens. And yet there is little or in fact no difference in the mechanism of the various kinds of voice, the variations in pitch being due chiefly to the greater length of the vocal cords in the low-pitched voices and to their shortness in the high voices. Tone, whether in speech or song, is simply a result of the action of a volume of air in a quantity which is regulated by the will of the speaker or singer, which, coming up from the lungs through the windpipe, passes up through the larynx, where it causes the elastic vocal cords to be put upon the stretch to a greater or less degree according as

the intended note is high or low, to vibrate, and thus is produced the tone which upon its entrance into the pharyngeal cavity and mouth becomes articulated, and the sound of which is variously and essentially modified according to the varying peculiarities of structure and formation of the larynx, pharynx, and mouth. It is also changed or modulated according as the various parts of the mouth, tongue, palate, teeth, and lips, assume different positions. Cultivation of the voice also impresses its stamp. The tone-waves, as they rush out of the open mouth, communicate their vibrations to the air, which conducts the sound onward until it reaches our ears, provided we are within the reach of these atmospheric vibrations. The difference between a cultivated voice or note is soon detected in the purity and regularity with which its sounds reach us as compared to the harsh, irregular, discordant waves impelled by one not so cultivated. Johannes Müller places the extreme range of the human voice at four octaves, but it is quite seldom that the range exceeds two and a half octaves. In some phenomenal voices, like those of the gifted Parepa-Rosa, Peschka-Leutner, Mara, Farinelli, and other great singers, we meet with astounding range and power. Parepa-Rosa had a voice ranging full three octaves, from sol_2 to sol_5; and Flint, the learned and indefatigable physiologist, tells that at the World's Musical Festival at Boston, in 1869, she gave the most astounding exhibitions of the wonders which this little organ, the larynx, is capable of.* In some of the solos by Madame Rosa, accompanied by a chorus of 12,000 with an orchestra of more than a thousand, and largely composed of brass instruments, Prof. Flint distinctly heard the pure and just notes of this remarkable soprano, standing alone, as it were, against the entire choral and instrumental force; and this in an immense building containing an audience of 40,000 persons! Mara's voice had compass, with equal fullness of tone, of three octaves, and she possessed such power of musical utterance that she imitated the most difficult passages of the violin and flute with perfect facility. Farinelli on one occasion competed with a trumpeter, who accompanied him in an aria. After both had several times dwelt on notes in which each sought to excel the other, they prolonged a note with a double trill in thirds, which they continued until both seemed exhausted. At last the trumpeter gave up, entirely out of breath, while Farinelli, without taking breath, prolonged the note with renewed volume of sound, trilling and ending finally with the most difficult roulades.

But these wonderful displays of the power of the larynx must not be ascribed entirely to the intensity of the tone, but are in no small measure due to the absolute mathematical equality of the sonorous vibrations and the comparative absence of discordant waves. By the degree of tension of the vocal cords which is required for the pitch of a prescribed tone, and which, as we have seen, is greater in the

higher and less in the lower notes, the muscles of the larynx really become the determining forces of the ability to sing, and a great deal depends upon securing for them the necessary practice, as for instance for the execution of rapid successions of tones. And herein lies the difference in the voices of singers, the purity of the tone depending upon the accuracy with which they put the vocal cords upon the stretch, while in those whose tones are impure and faulty, the difficulty lies in their inability to give the requisite tension, and of course the muscles take part in the shortcoming. A correct idea of the sound, height, and depth, of the tone which the singer intends to communicate, enables him to strike the correct tension as by intuition, and carries him along its continuance, and through its purity of modulation, until it has ceased.

DR. DRAPER'S LECTURE ON EVOLUTION.[1]

ITS ORIGIN, PROGRESS, AND CONSEQUENCES.

WHEN, in the beginning of the present year, I received a request to deliver before this Institute a lecture on the subject of Evolution, I was at first disposed to excuse myself. Holding religious views which, perhaps, in many respects are not in accordance with those that have commended themselves to you, I was reluctant to present for your consideration a topic which, though it is in truth purely scientific, is yet connected with some of the most important and imposing theological dogmas. Whatever conclusion is eventually reached respecting it will have an influence on them. But there was that liberality of sentiment in your letter—that earnest desire for the ascertainment of truth—that I cast aside these hesitations, and am now here in obedience to your wishes.

Not that I can do justice in an hour to so great a subject, the literature of which ranges through many centuries. It is no new-fangled romance, as some would have us believe. It comes to us from a venerable antiquity. The theorems it expresses, and indeed on which it is based, have long ago been clearly known.

Considering the shortness of the time allotted me, the vast extent of the subject, the special character of this audience, and the nature of your request, I perceive that it is not an elaborate exposition of the evidence in favor of the theory of evolution that I must

[1] The ministers of the Unitarian Church have recently held a meeting of their Institute at Springfield, Massachusetts. They had requested Dr. John W. Draper to deliver before them a lecture on the subject of Evolution. This accordingly was done on Thursday, October 11th. Some passages omitted in the lecture for want of time are here introduced.

give, but a reference to those facts connected with it that are of chief interest to you. I must bear in mind that this is an institute of clergymen seeking information on a topic which they consider to have a bearing on their pursuits, and that it is from a corresponding point of view that I must present it.

Two explanations have been introduced to account for the origin of the assemblage of organic beings, plant and animal, that surround us. These are conveniently designated as the hypothesis of Creation and that of Evolution.

The hypothesis of CREATION asserts that Almighty God called into sudden existence, according to his good pleasure, the different types of life that we see. This hypothesis has an ecclesiastical form, that the world, with all its various animals and plants, was created about six thousand years ago. The work was completed in six days, and was perfect, needing no improvement. At the close of each day the Almighty surveyed what he had done, and pronounced it very good. He brought all the animals thus made before Adam in the garden of Eden to receive their names. There was nothing more necessary, and on the seventh day he rested.

The hypothesis of EVOLUTION asserts that from one or a few original organisms all those that we see have been derived, by a process of evolving or development. It will not admit that there has been any intervention of the divine power.

The former of these hypotheses considers each species as independent of all the others; the second considers them as inter-related. Creation reposes on the arbitrary act of God: Evolution on the universal reign of law.

The hypothesis of Evolution in its scientific form presents three factors: 1. Heredity; 2. Environment; 3. Adaptation. By heredity is meant the tendency manifested by an organism to develop in the likeness of its progenitor. By environment, the sum total of the physical conditions by which the developing organism is surrounded—the ambient world. By adaptation, the disposition so to modify as to bring an organism and its environment into harmony. This may be accomplished either by progression or retrogression.

As to the origin of organisms, it withholds, for the present, any definite expression. There are, however, many naturalists who incline to believe in spontaneous generation. In its most improved form it occupies itself with two classes of problems, the direct and the inverse, considering in the former the effect of the environment on the organism, and in the latter deducing from the organism the nature of the environment. Thus Schleiden gathers from the structure of the stems of certain pine-trees the distribution of climates at the time of their growth; and the ancient geographical connections of Madagascar and of Australia may be thus ascertained from their fauna.

After a very long and exhaustive survey of the plants and animals of his own locality, and of all that the power and favor of Alexander the Great enabled him to inspect, this is the result to which Aristotle, the prince of ancient Greek naturalists, came. In the eighth book of his "History of Animals," when speaking of the chain of living things, he says: "Nature passes so gradually from inanimate to animate things, that from their continuity the boundary between them is indistinct. The race of plants succeeds immediately that of inanimate objects, and these differ from each other in the proportion of life in which they participate; for, compared with minerals, plants appear to possess life, though when compared with animals they appear inanimate. The change from plants to animals is gradual; a person might question to which of these classes some marine objects belong." Aristotle referred the primitive organisms to spontaneous generation.

In the Museum of Alexandria the views of Aristotle were greatly expanded. There it was discovered that animated Nature presents something more than a mere connection; that each link of Aristotle's chain, if such a phraseology must be continued, was the descendant of its predecessor, the progenitor of its successor. The idea now lost its mechanical aspect and assumed a physiological one.

We remark an important extension of this view after the conquest of Alexandria by the Arabians. If we compare the order of affiliation in successive points, it obviously presents a new fact—progress; and not progress only, but progress from the imperfect to the more perfect. This view included lifeless as well as living Nature. A practical application of it arose, to which the designation Alchemy was given. There is an unceasing progression, in which all things take part, to a better and nobler state. In this slow development Nature has no need to hasten; she has eternity to work in. Thus, in the mineral world, base and unworthy metals, such as lead and tin, are slowly on their way to perfection. They reach their goal on turning into gold. It is, then, for us to ascertain the favoring conditions, and, by imitating or increasing them, to hasten on the work.

The literature of those ages is pervaded with the idea of the mutability of everything—a proneness of all living beings to suffer transmutation, with changes in the environment, or in the physical conditions to which they are exposed; and thus arises a slow but continuous procession, in the unceasing lapse of time, to the beautiful and good. We meet with this in both the serious philosophical works of the Mohammedans, and in their lighter compositions of romance. They wrote books on the production of animals both by generation and putrefaction. They thought that in the germ there exists a latent force tending to evolve it. Ibn Roschd says: "There are, as respects the origin of living beings, two opposite theories. Some explain their existence by development, others by creation. The latter is the opinion of the Christians, as well as of our Motacallemin." Abubacer

accepts the reality of spontaneous generation by means of putrefaction and the action of the sun. These philosophers did not hesitate to say that the dogma of creation is an impossibility, an absurd opinion, only fit for the vulgar who will believe anything. According to these elevated views, living beings are merely a movement of matter under the influence of heat. Man himself is like the flame of a lamp, a form or shape through which material substance is passing, receiving supplies, dismissing wastes, and evolving force. As regards transmutation, Al Khazini says that an animal passes through successive stages of development, but we must not suppose that naturalists mean to say that "man was once a bull, and was changed into an ass, and afterward into a horse, and after that into an ape, and finally became a man."

Arabian philosophers had therefore speculated on spontaneous generation, and the conditions necessary for its occurrence; on the development of a germ by the latent force it contains; on the transmutation of species; and the production of the animal series. They had rejected the theory of creation, and adopted that of evolution. They had gained ideas respecting the unceasing dominion of law, but at these they had arrived through their doctrine of emanation and absorption, rather than from an investigation of visible Nature. In the religious revolt against philosophy that took place toward the twelfth century, these ideas were exterminated and never again appeared in Islam.

If the doctrine of the government of the world by law was thus held in detestation by Islam, it was still more bitterly refused by Christendom, in which the possibility of changing the divine purposes was carried to its extreme by the invocation of angels and saints, and great gains accrued to the Church through its supposed influence in procuring these miraculous interventions. The Papal Government was no more disposed to tolerate universal and irreversible law than its Paynim antagonist had been. The Inquisition had been invented and set at work. It speedily put an end, not only in the south of France, but all over Europe, to everything supposed to be not in harmony with the orthodox faith, by instituting a reign of terror.

The Reign of Terror in revolutionary France lasted but a few months; the atrocities of the Commune at the close of the Franco-German War only a few days; but the Reign of Terror in Christendom has continued from the thirteenth century with declining energy to our times. Its object has been the forcible subjugation of thought.

The Mohammedans had thus brought the theory of evolution up to that point at which, for any further advance, clear views of the operation of law in the government of the world were necessary. In their speculations in this particular they had been guided by theological

considerations. These were now to be replaced by others of a more definite and solid kind, derived from physical science.

The starting-point of Christendom in the theory of evolution, for the Mohammedans had now ceased to philosophize, was the publication by Copernicus of the book "De Revolutionibus Orbium Celestium." In this the Pythagorean view of the emplacement of the solar system was revived. The way for this restoration had been prepared by such books as that of Cusa "On Learned Ignorance." He conceived of the universe as a vast organism, the life of which is the breath of God, and which has neither centre nor circumference, but is infinite as its maker. Such views were largely prevalent in Italy, at that time the focus of infidelity, and there Copernicus had been. His work was followed by Kepler's great discovery of the three laws that bear his name.

After the invention of printing, the "Index Expurgatorius" of prohibited books had become essentially necessary to the religious Reign of Terror, and for the stifling of the intellectual development of man. The Papal Government, accordingly, established the Congregation of that Index.

It was very plain that the tendency of Kepler's discoveries was to confirm the dominating influence of law in the solar system, as well as to destroy geocentric and anthropocentric theories. It was, therefore, adverse to the Italian theological views, and to the current religious practices. Kepler had published an epitome of the Copernican theory. This, as also the book itself of Copernicus, was placed in the Index, and forbidden to be read.

The Reformation came. It did not much change the matter. It insisted on the Mosaic views, and would tolerate no natural science that did not accord with them. Nevertheless, under the shadow of the political power it shortly gathered, Newton's "Principia" was safely published. The two great powers into which Christendom was divided held each other in check. The sectarian divisions fast springing up in Protestantism found occupation in their contentions with each other. The bearing which Newton's book had upon those already condemned consisted chiefly in this—it gave indisputable reasons that Kepler's laws are a mathematical necessity. For the finger of Providence it substituted mechanical force. And thus the Reign of Law, that great essential to the theory of evolution, was solidly established.

But not alone did the discoveries of physical astronomy lead to these views. If the heavens were observed, the earth, also, was examined. There could no longer be any doubt that fossil remains were the relics of beings that were once alive, as Xenophanes in the old times, and Da Vinci and Palissy more recently, had affirmed—not mere *lusus naturæ;* that the earth's strata were not all of the same age; that in the oldest no fossils could be found; that there had been

a time when there was no life on the earth; that of the strata some are of marine, some of fresh-water formation; that they are often intercalated like leaves in a book, and therefore cannot be referred to any single cataclysm such as the deluge.

From considerations connected with the primary rocks, Leibnitz (1680) had inferred that the earth was once at a far higher temperature than now, and in fact must have been in an ignited state; that it had undergone a gradual cooling. Werner subsequently introduced the Neptunic theory, and Hutton the Plutonic. These cosmographical theories were, however, of less importance than what was done in paleontology. It was discovered that while similar fossil remains extend over vast horizontal surfaces, different fossils are found to succeed each other very rapidly when a vertical examination is made. There is a geological as well as a geographical distribution of plants and animals—geological as to time, geographical as to surface.

In the works of Maillet (1748), and again in those of Buffon, the old doctrine of evolution reappears. A more formal presentment was, however, made by Lamarck in his "Philosophie zoologique," published in 1809. He advocated the doctrine of descent, and announced the propositions now known as Darwinism. According to him, organic forms originated by spontaneous generation, the simplest coming first, and the complex being evolved from them. Variations and transmutations occur through external influences, the environment modifying the organism, and as these in the lapse of time become essential differences, new species arise. Moreover, wants experienced cause the will to develop new organs by the modification of previously-existing ones, and these are transmitted by heredity or generation. Organisms are developed out of one another; so far from being permanent, they have only a temporary existence.

Though an organism tends to be like its progenitor, it will undergo changes by the use or disuse of its parts; by the former it is developed, by the latter deteriorated. The changes produced thus, or by the environment, always have been, and always will be, continuous, not catastrophic.

Lamarck recognized the struggle of each against all. He saw plainly the influence of heredity, and understood the relation of environment and adaptation. He defined in the clearest manner the doctrine of transmutation and theory of descent. According to him, if time enough be allowed, any modification may take place.

So far from meeting with acceptance, the ideas of Lamarck brought upon him ridicule and obloquy. He was as much misrepresented as in former times the Arabian Nature-philosophers had been. The great influence of Cuvier, who had made himself a champion of the doctrine of permanence of species, caused Lamarck's views to be silently ignored, or, if by chance they were referred to, denounced. They were

condemned as morally reprehensible and theologically dangerous. In this, the authority of Cuvier in regard to evolution acted as the authority of Newton had done in regard to the undulatory theory of light.

In like manner the views of Oken met with resistance, especially his deduction that the highest animals are the result of development, not of creation. Man, he significantly says, has been developed, not created. He conceived all Nature to be in a process of evolution. His demonstration, that the bones of the skull are only vertebral modifications, however, reconciled many persons to a more favorable opinion of his hypothesis of development.

Geoffroy St.-Hilaire (1828) did not doubt that animals now living are descended by an unbroken succession from extinct ones, by transformation from form to form; that different species are degenerations of the same type, being due to the influence of the environment (*monde ambiant*). He thus became the opponent of Cuvier, and did very much to break down the influence of that zoölogist. In these variations he considered that the organism is passive, differing in this from Lamarck, who thought it active. His views of the influence of the environment were very precise: thus he thought that birds arose from reptiles, through the diminution of carbonic acid and increase of oxygen in the air, at the time of the formation of coal; the activity of the animal circulation becoming greater, and the reptile scales being transformed into the feathers of the bird. As is now known, this was substantially a correct interpretation.

Though the principles of the doctrine of evolution were thus thoroughly understood, the control of heredity, the influence of environment, the modeling by adaptation, public attention failed to be drawn to it until 1844, when there was published in England an anonymous book under the title of the "Vestiges of the Natural History of Creation." In this the author set forth Lamarck's views, and the work, being clearly and attractively composed, passed through a great many editions. Very fortunately, it may be said, it accepted some unsubstantiated facts and contained some physical mistakes. These tempted many skillful and bitter criticisms of hostile theologians. The reviews and journals were filled with their attacks and answers to them. Thus, happily, the whole subject was brought into such prominence that it could be withdrawn into obscurity no more.

In the discussions of this book the author made use of a most important anatomical discovery, that even in the case of the highest species, man himself, the embryo does not simply grow or increase in size, but passes in succession through a series of forms, which, examined from epoch to epoch, are totally dissimilar. It had been the vulgar opinion that after the first moment of conception all the parts of the animal that is to be are present, and that they simply grow. The human embryo, according to this, reaches birth very much in the

same way that the infant passes from birth to manhood. That was, I say, the vulgar opinion, but, in laying before our eyes the development of the individual, God has given us a revelation of the course of life by the world.

The evolutionary history of animals establishes that there is not this homogeneousness of development, but that the higher pass through the forms of the lower; that the mammal, for instance, passes through stages at which the lower vertebrates remain fixed. All are therefore pursuing a journey along the same road, though some may travel to a longer, some to a shorter, distance. There is thus a parallelism between individual and race development; a close connection between the phases of development in the individual and in the species.

The type of each animal is from the first as it were imbedded in the embryo and controls its evolvement. The embryo never makes any attempt to change from one type to another, but sometimes the tendency to a form and not the form itself is transmitted.

The parallelism that exists between the career of the individual and the career of the race reappears in the life of the world. There is a resemblance—indeed more than a resemblance—between the successive forms through which man himself in his prenatal life has passed, and those that have appeared in myriads of ages in the biography of the earth. Common-sense revolts against the idea that these transformations are in the individual due to divine intervention. In that, and in the case of the earth, they must be due to natural law.

In the year 1859 there was published by Mr. Darwin a work on "The Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life."

In this, and in other subsequent works, it is shown that the individuals of each species tend to increase in a very rapid ratio—an increase more rapid than that of their means of subsistence. Each has, therefore, to contend with his competitors; and hence all must exhibit "a struggle for existence."

But modifications are incessantly taking place in the form and characteristics of individuals, giving to some an advantage, to some a disadvantage, as compared with their competitors. Hence, the former will prevail, the latter will succumb in the struggle. This in the language of the hypothesis is formulated "the survival of the fittest."

And as the pigeon-fancier or other person who devotes himself to the breeding of animals can produce any form he wishes by selecting its progenitors and pairing them together, exercising thus artificial selection, so if any of the chance-forms that have arisen should be better adapted than others for perpetuation, they will be perpetuated, or Nature may be said to have made a selection. Hence the term "natural selection," which has been made to designate this hypothesis.

It is to be regretted that this phrase "natural selection" has been introduced. It is very unscientific, very inferior to the old expression adaptation. It implies a personification of Nature. It is anthropomorphic. But Nature never selects, never accepts or rejects, knows nothing about duties, nothing about fitness or unfitness. Nature simply obeys laws.

Natural selection is thus supposed to perpetuate an organism after adaptation to its environment has taken place. The change implied by adaptation must precede it. It should be regarded rather as a metaphorical expression than a scientific statement of an actual physical event.

Darwinism, therefore, does not touch the great question as to the manner in which variation of organisms arises. It only teaches how such variations are perpetuated.

The publication of Humboldt's "Essay on the Geography of Plants" (1805) first formally drew the attention of botanists to the connection between the distribution of plants and the distribution of heat on the surface of the earth. As an advance is made from the equator toward the pole in either hemisphere, the mean annual temperature declines, and in succession a series of vegetable zones is encountered, merging gradually into each other, though each, where best marked, is perfectly distinguished from its successor. In the tropics there are the palms which give so striking a characteristic to the landscape, the broad-leaved bananas, and great climbing plants throwing themselves from stem to stem like the rigging of a ship. Next follows a zone of evergreen woods, in which the orange and citron come to perfection. Beyond this, another of deciduous trees, the oak, the chestnut, and the fruit-trees of our orchards. Here the great climbers of the tropics are replaced by the hop and the ivy. Still farther is a belt of conifers, firs, larches, pines, and other needle-leaved trees; and these lead through a range of birches, becoming more and more stunted, to a region of mosses and saxifrages, but which at length has no tree nor shrub; and finally, as the perpetual polar ices are reached, the red-snow alga is the last trace of vegetable organization.

A similar series of facts had long previously been observed by Tournefort in an ascent of Mount Ararat. The distribution of vegetation from the base to the top of the mountain bears a general resemblance to the distribution from the base to the polar regions. These facts were generalized by subsequent observers. It was established that there exists an analogy between horizontal distribution on the surface of the globe, and vertical distribution at different altitudes above the level of the sea. Even in the tropics, if a mountain be sufficiently high, a short ascent suffices to carry us from the characteristic endogenous growths at its foot through a zone of evergreens

into one of deciduous trees, and this again into one of conifers, the vegetation declining through mosses and lichens as we reach the region of perpetual snow.

In these cases of horizontal and vertical distribution which thus present such a striking botanical resemblance, there is likewise so clear a meteorological analogy that it is impossible to avoid the conclusion that the distribution of plants depends very largely on the distribution of heat. And, indeed, what better illustration of the influence of heat could we have than this, that by artificially adjusting the temperature of hot-houses we can cause any plant to grow in any latitude?

But temperature alone does not determine the distribution of plants. If it did, we should find the same species in the same isothermal zones. Throughout the old continent, with the exception of the torrid zone, heaths abound; but in America not a single heath occurs. In the New World, through forty degrees on each side of the equator, the cactus tribe flourishes; in the Old not a single cactus is to be seen —the spurges there replace them. So, again, in Australia, the forests present a melancholy, a shadeless character, from their casuarinas, acacias, eucalypti, whereas, if temperature alone were concerned, they should offer the same aspect as the forests of North America and Europe.

As regards animals the same remark may be made. In the temperate zone, eastward beyond the Caspian, there are men whose complexion is yellow; in Europe the complexion is white; the American Indian is red. Asia has its Tibet bear, Europe its brown bear, North America its black bear. The European stag finds in America its analogue in the wapiti, its Asiatic in the musk-deer. The wild-ox of Lithuania differs from the North American buffalo, and this, again, from the Mongolian yak. The llama in America replaces the camel of Asia, the puma replaces the lion. Brazil has had in times long past representatives of its existing sloths and armadillos. Australia, which has isothermal zones like those of other continents, has no apes or monkeys, no cats or tigers, no wolves or bears, hyenas, horses, squirrels, rabbits; no woodpeckers or pheasants. Instead of them it has the kangaroo, wombat, ornithorhynchus, cockatoos, and lories, nowhere else found.

Then, though heat is a dominating influence in the distribution of plants and animals, it is by no means the only one. There are also other conditions, such as the supply of water, the composition of the soil, the access of light, etc. It has been found convenient to group all these together, and to speak of them, as I have already stated, under a single designation, "The Environment."

Change in the environment, and change in its organisms, go hand-in-hand. Should the warmth of the tropics be diffused into the polar circle, a tropical vegetation would replace the vanishing snows.

Should the ices of the poles spread over the temperate region, the reindeer would accompany their invading edge.

While the environment thus influences the organism, the organism reacting influences the environment. The most striking instance of this, perhaps, will be found on comparing the constitution of the atmosphere before and since the Carboniferous epoch. Prior to that epoch, all the myriads of tons of coaly substance now inclosed in the strata of the earth existed as carbonic acid in the air. By the agency of the sunlight acting on the leaves of the luxuriant vegetation of those times, this noxious gas was gradually removed, and replaced by an equivalent volume of oxygen. A hot-blooded, quickly-respiring animal could not possibly exist in an atmosphere laden with carbonic acid. Anterior to the coal deposit, the fauna was cold-blooded and slow-respiring. The flora thus changed the aërial environment, and this, in its turn, reacting, changed the fauna.

It is on all sides admitted that plants tend by their removal of carbonic acid from the air, replacing it by oxygen, to compensate for the disturbance occasioned by animals. In this way, through very many centuries, the same percentage constitution of the atmosphere is maintained, the sum total of vegetable being automatically adjusted to the sum total of animal life—automatically, and not by any interference of Providence—a fact of great value in its connection with the theory of evolution. For, if we admit what has been conclusively established by direct experiment, that plants would grow more luxuriantly in an atmosphere somewhat richer in carbonic acid than the existing one, we may see how upon this condition depends a principle of conservation, which must forever retain the air at its present constitution, no matter how animal life may vary.

Cuvier speaks of the inferior organisms as furnishing us with a series of experiments made by the hand of Nature, an idea often quoted and often admired, but which, perhaps, is scarcely consistent with enlarged conceptions of the system of the world. An organism, no matter how high or low, is not in an attitude of isolation. It is connected by intimate bonds with those above and those beneath. It is no product of an experimental attempt, which, either on the part of Nature or otherwise, has ended in failure or only partial success.

The organic series—an expression full of significance and full of truth implies the interconnection of all organic forms—the organic series is not the result of numberless creative blunders, abortive attempts or freaks of Nature. It presents a far nobler aspect. Every member of it, even the humblest plant, is perfect in itself. From a common origin, or simple cell, all have arisen; there is no perceptible microscopic difference between the primordial vesicle which is to produce the lowest plant, and that which is to produce the highest, but the one, under the favoring circumstances to which it has been exposed,

has continued in the march of development, while the career of the other has been stopped at an earlier point. The organic aspect, at last assumed, is the representation of the physical agencies that have been at work—the environment. Had these for any reason varied, that variation would at once have been expressed in the resulting form, which is, therefore, actually a geometrical embodiment of the antecedent physical conditions. For what reason is an offspring like its parent, except that it has been exposed during development to the same conditions as was its parent. Comparative physiology is not a fortuitous collection of experiments. Our noblest conception of it is the conception we have of analytical geometry. Each member of the organic series is an embodied result of a discussion of the equation of life for one special case.

It was a felicitous thought of Descartes that we may represent a geometrical form in an algebraic equation, and, by the proper consideration and discussion of such an expression, determine and delineate all the peculiarities of such a form; that here it should become concave, there convex; here it should run out to infinity, there have a cusp. The equation determines all the peculiarities of the form, and enables us to construct it. In like manner, all living and lifeless forms are related; an increase in the value of one condition carries development forward in one direction; an increase in the value of another condition determines development in another way, and these variations give rise in their succession to the whole organic series.

Nature ever geometrizes and ever materializes. Every organism is the result of the development of a vesicle, under given conclusions, carried out into material execution. It is the incarnation, the embodiment, the lasting register of physical influences, the daughter of the environment.

Let us now rapidly survey the changes that have taken place in the earth's organisms:

In the earliest, or Primordial period, there existed of plants only water-organisms—tangled sea-weeds. Then in the following, the Primary, came the more perfect cryptogams, such as ferns. Then followed, in the Secondary, pine-forests. In the Coal period the phanerogamia developed out of the more perfect cryptogamia. Not until the Chalk did the higher corollifloræ appear. In the beginning of the Tertiary the earth had sufficiently cooled at the poles, climate-zones were produced, and the land was covered with leaved forests. Flowerless plants had been succeeded by flowering ones, the latter first without a distinct corolla, and then by those with one; and of these, first the lower and then the higher.

Turning to the order of succession of animal life—of the Primordial, the forms are skull-less; then in the following, the Primary, came fishes, first those with the heterocercal tail, as in the embryos of

existing ones. In the Secondary, reptiles, and out of them birds, were developed; the decreasing amount of carbonic acid and the increasing amount of oxygen permitting that change. Of birds, the earliest had a long, lizard-like tail, composed of thin vertebræ, to every one of which were attached strong, rudder-like feathers in pairs. The same formation of the tail part of the vertebral column still occurs transiently in the embryos of later birds. The transition from the reptile to the bird is manifested by some of the latter having teeth set in one order in grooves, in another in distinct sockets. Among mammals as among fishes the imperfect appeared first. About the middle of the Mesolithic period, out of a branch of the cloacal animals the marsupials were evolved; and in the beginning of the Tertiary the placentals were developed out of the marsupials. The latter were at one time distributed over the whole earth; now they are fast approaching extinction. In Europe, Asia, Africa, not a single member of the group remains. The cloacal animals, the marsupials, the placentals, stand therefore in an order of succession.

Such has been the order of evolution in Europe. For its order in America I may refer you to the recent admirable address of Prof. Marsh before the American Association for the Advancement of Science. The general conclusions at which we arrive in one case are substantiated in the other.

In accordance with his descent, the cloacal structure exists in man in the earlier period of his embryonic life. The separation into two openings takes place about the twelfth week of his uterine development. Shall we not, therefore, infer from the evidence of his embryonic forms that he has been developed step by step out of the lower vertebrates?

In the early stages of their evolution, amphibia, reptiles, birds, cannot be distinguished. The first steps of development in all vertebrates are identical. Man passes now through the same series of transmutations which his animal predecessors passed through in immense spaces of time, long ago. The progress he makes in the lapse of a few days in the darkness of the womb is the same that has been followed by the procession of animated Nature in the lapse of myriads of centuries in the daylight of the world.

From a comparison of their studies embryologists and paleontologists unite in the conclusion that individual development is a rapid repetition of race-development, and that the paleontological movement is to be interpreted by the embryonic. The connecting links supposed to be missing in the former may be sought for in the latter. Individual development, paleontological development, and comparative anatomy, through their combined evidence guide us to a deduction of the genealogy of any organism. The dominion of law is everywhere manifest. The capricious intrusion of a supernatural agency has never yet occurred.

Each of the geological periods has its dominating representative type of life. Perhaps it may be asked: "How can we be satisfied that the members of this long series are strictly the successive descendants by evolution from older forms, and in their turn the progenitors of the later? How do we know that they have not been introduced by sudden creations, and removed by sudden extinctions?" Simply for this reason: The new groups make their appearance while yet their predecessors are in full vigor. They come under an imperfect model which very gradually improves. Evolution implies such lapses of time. Creation is a sudden affair.

A striking illustration of this is offered by two of the most imposing types of life, the reptile and the mammal. The former is the characteristic of the Secondary, the latter of the Tertiary period. In the Secondary, when reptile life was at its culmination, there were reptiles flying in the air, swimming on or in the sea, crawling on the land, or climbing the trees. After this type of life had reached its culmination, and extinction began to set in, that process went forward in a gradual and orderly way. The flying lizards were the first to disappear, then those of the sea; they now have scarcely any representative left. The fluviatile and terrestrial ones, though greatly diminished both in numbers and size, still maintain a struggle for life; but the complete dying out of animated forms, though irresistible, requires for its completion countless centuries.

While reptile life was in full vigor, mammal life was introduced. It came under the lowest forms, the imperfect orders appearing first.

What does this coexistence of two different forms of life, through immense lapses of time—the one declining and on its way to disappearance, the other marching forward to increase—what does this overlapping mean? Not sudden creation, but slow development. The environment is slowly becoming unsuitable to the one, and slowly becoming suitable to the other.

If time permitted, I would ask your close attention to rudimentary organs, for they illustrate strikingly the theory of evolution. They are organs existing in an apparently undeveloped and useless condition, such, for instance, as the incisor teeth in the midbone of the upper jaw in embryos of common cattle, the rudimentary wings of the penguin and dodo, the mammæ of the male mammalian, the subcutaneous feet of certain snakes. In the embryos of whales teeth are found in the jaw, precisely as we find them at birth in the human infant. In the latter instance, we think we see a wise provision and foresight of Nature, which does not give to man these masticatory organs before the time they are wanted. But what are we to make of the parallel case of the whale? Shut up as these rudimentary teeth are in the interior of the jaw, never to be developed and never to be used, does not that look something like a useless work? And why has Nature,

in the case of certain snakes, placed under the skin bony representatives of the extremities, the movements of those animals being by the use of the ribs, and feet never being wanted?

We may also turn to the vegetable world, and there we find rudimentary organs, excesses and deficiences of development. As Treviranus says, adaptation to the surrounding world may be shaped either by gradual development or by degeneration, which is equally effective. The same organ may be expanded into a compound leaf, or degenerated into a scale. Development can turn a reptile into a bird; degeneration can turn it into a serpent. Any flower may be regarded as a transformed branch—that which might have evolved into a leaf turns indifferently, as circumstances may direct, into a sepal, a petal, or a stamen.

Rudimentary organs come into existence as part of a general plan. They are the manifestation of heredity in the type of life of the animals or plants in which they occur. They prove that the form has been developing, not teleologically, or for a purpose, but in obedience to law.

Now I have answered, and I know how imperfectly, your question, "How does the hypothesis of evolution force itself upon the student of modern science?" by relating how it has forced itself upon me, for my life has been spent in such studies, and it is by meditating on facts like those I have here exposed that this hypothesis now stands before me as one of the verities of Nature.

In doing this I have opened before you a page of the book of Nature—that book which dates from eternity and embraces infinitude. It reveals millions of suns and worlds of surpassing glory. Among its most insignificant pages are the vast rock-strata of the earth. We have been looking at some of them. No Council of Laodicea, no Tridentine Council, is wanted to indorse its authenticity, nothing to assure us that it has never been tampered with by any guild of men, to perpetuate their influence, secure their profits, or otherwise promote their ends.

Then it is for us to study it as best we may, and to obey its guidance, no matter whither it may lead us.

And this brings me face to face with the third division of my subject. I have spoken of the origin and the progress of the hypothesis of evolution, and should now consider the consequences of accepting it. Here it is only a word or two that time permits, and very few words must suffice. I must bear in mind that it is the consequences from your point of view to which I must allude. Should I speak of the manner in which scientific thought is affected, should I dwell on the influence this theory is exerting on general knowledge, I should be carried altogether beyond the limits of the present hour.

The consequences! What are they, then, to you? Nobler views

of this grand universe of which we form a part, nobler views of the manner in which it has been developed in past times to its present state, nobler views of the laws by which it is now maintained, nobler expectations as to its future. We stand in presence of the unshackled, as to Force; of the immeasurable, as to Space; of the unlimited, as to Time. Above all, our conceptions of the unchangeable purposes, the awful majesty of the Supreme Being, become more vivid. We realize what is meant when it is said, "With HIM there is no variableness, no shadow of turning." Need I say anything more in commending the doctrine of evolution to you?

Let us bear in mind the warning of history. The heaviest blow the Holy Scriptures have ever received was inflicted by no infidel, but by ecclesiastical authority itself. When the works of Copernicus and of Kepler were put in the Index of prohibited books, the system of the former was declared, by what called itself the Christian Church, to be "that false Pythagorean system, utterly contrary to the Holy Scriptures." But the truth of the Copernican system is now established.

There are persons who declare of the hypothesis of evolution, as was formerly declared of the hypothesis of Copernicus, "It is utterly contrary to the Holy Scriptures." It is for you to examine whether this be so, and, if so, to find a means of reconciliation. Let us not be led astray by the clamors of those who, not seeking the truth and not caring about it, are only championing their sect, or attempting the perpetuation of their own profits.

My friends, let me plead with you. Don't reject the theory of evolution. There is no thought of modern times that more magnifies the unutterable glory of Almighty God! Remember, I beseech you, what was said by one of old times: "Ye men of Israel, take heed to yourselves what ye intend to do. And now I say unto you, if this counsel be of men it will come to naught; but if it be of God, ye cannot overthrow it, lest haply ye be found to be fighting against God"—shall I continue the quotation?—"and to him they all agreed!"

We often hear it affirmed that our age is becoming more and more irreligious, and that men wantonly reject sacred things of which their ancestors approved. But I think we may profitably inquire whether very much of this is not due to the profound changes that are taking place in our conceptions of the Supreme Being? Things and acts which at one time men attributed to him without hesitation, they can attribute to him no more. They have learned to demand of every dogma, "Is it derogatory to the awful majesty of God?"

These modifications of opinion have had no little to do with the progress of the subject we have been considering. Let us ever bear in mind that the doctrine of evolution has for its foundation not the admisssion of incessant divine interventions, but a recognition of the

original, the immutable fiat of God. In whatever direction we commune with Nature, the dominion of universal, of everlasting law confronts us.

The establishment of the theory of evolution has not been due to any one science, but is attributable to the conjoint movement of all. It is due to the irresistible advance of human knowledge. To refer it to geology alone, as is often done, is altogether a mistake. It was not possible that Astronomy should fail to maintain her grand position. She took the lead in the intellectual revolution which marks the close of the middle ages. Single-handed and alone, she fought and won the great battles of the globular form of the earth, the central sun, the plurality of worlds. It cost her the blood of some of her leaders. For some there was the fagot, the rack, the prison-cell, the scourge. But they departed from their tormentors, rejoicing that they were accounted worthy to suffer even death in this cause. And now she found stepping-stones for herself in the trackless infinitude of space, and beckoned her comrade sciences to come and share with her the glorious view she had gained of the majesty of the universe. Anatomy, both human and comparative, paleontology, chemistry, physiology, microscopy, even philosophical history, have given their aid. Wherever any one science has made a marked advance, its movement has been covered by some of the others, and the ground thus occupied secured. As matters now stand, all are well to the front—the entire line is dressed.

It often takes many victories to establish one conquest. Knowledge, fresh from so many triumphs, unfalteringly continues her movement on the works of Superstition and Ignorance.

Now, in parting, let us bear this in mind: So great is the intellectual advance men have made, that questions which at one time divided Christendom into sects are now far in the rear. Those which once separated good men socially, are passing out of sight. They are replaced by others of a very different order. Among such, one of surpassing importance confronts us—the eternal reign of law. Let us bear in mind what the theory of evolution so loudly proclaims: "We are what we are, because the universe is what it is." If it acts upon us, we react upon it. Our conception of the sphere of being we occupy is enlarging, and we are thus brought into close relationship with all that is beautiful on earth, all that is magnificent in the heavens.

Then let us reverently commune with Nature. Let us try to raise our eyes from the varying phenomena of the world, to the solemn grandeur of that silent, that imperishable reign of law that governs all those changes; let each of us earnestly address to himself the remonstrance of "The Minstrel:"

> "Oh! how canst thou renounce the boundless store
> Of charms that Nature to her votary yields,

The warbling woodland, the resounding shore,
The gloom of groves, the garniture of fields,
All that the genial ray of morning gilds,
And all that echoes to the song of even,
All that the mountain's sheltering bosom shields,
And all the dread magnificence of heaven—
Oh! how canst thou renounce, and hope to be forgiven?"

THE GREAT BENGAL CYCLONE OF 1876.[1]

By CARL DAMBECK.

NO more convincing proof could, perhaps, be given of the headlong pace of our modern life, or of the thoughtlessness of our age, than the fact that, though we still hear of the earthquake at Lisbon, hardly a word is said of the fearfully destructive cyclone which, on the 31st of October, 1876, swept over the Delta of the Ganges. Even in the queen's last speech from the throne, there is not so much as a simple mention of that disastrous event, whereby a quarter of a million of British subjects in India were destroyed. The after-effects of the cyclone in themselves constituted a fearful calamity, for thousands are still[2] dying of disease and hunger—evils the seeds of which had been sown in October.

Cyclones usually occur toward the end of spring and in the fall—from April to June, and from September till November—the periods of the change of direction in the monsoons. By far the greater number of the cyclones occur at the cessation of the southwest and the setting in of the northeast monsoons in the fall: out of eighty-eight observed in the Indian Ocean, forty-nine occurred in the fall and only twenty-nine in the spring. The former, almost without an exception, came from a point lying somewhat to the north of latitude 15° north, in the bay of Bengal; while the latter had their rise in the neighborhood of the Andaman Islands. The whole east coast of India is exposed to the fury of these storms, and from Ceylon to Chittagong there is hardly a point on the coast that has not more or less frequently felt the power of the cyclones, though the localities which suffer most are the low-lying portions of the coast, more particularly when they are situated in a bight or in an angle, for wind and water are there brought into violent conflict. One of the earliest cylones of which authentic accounts are extant occurred in 1789, at an unusual season of the year—December. Furthermore, it was attended by three enormous storm-waves, which flooded the coast at Coringa,

[1] Translated from the German, by J. Fitzgerald, A. M.

[2] May, 1877, when this article was written.

near the mouth of the Godavary, destroying nearly the entire town with its 30,000 inhabitants, and driving far inland the ships which lay at anchor in the bay. In 1839 the same locality was visited by another cyclone, which was nearly as destructive as the preceding. The coast of Madras and of Coromandel has again and again been the theatre of cyclones, though here the wave is not so destructive in its effects as elsewhere, owing to the situation and the formation of the coast. In Madras the cyclone usually appears to expend its fury on the many ships at anchor in the roads, and on the buildings on the land, as was the case in the years 1773, 1783, and 1872. As on October 15, 1783, so on the 1st and 2d of May, 1872, an enormous amount of shipping was lost. In the latter case the greater part of the vessels might have put out to sea, if the officer of the port had been at his station and given warning in time. The destruction of life and property caused by the wind and rain, as also by the swell of the sea, was very considerable. Another cyclone which on October 15 and 16, 1874, swept the inland districts of Midnapore and Burderan, claimed but few victims comparatively: in Midnapore only about 3,000 persons lost their lives, while in Burderan there were but a few fatal casualties. Of all the coasts of India the mouths of the Ganges and the Hooghly appear to have suffered oftenest and most severely from this catastrophe, for there wind and water are, as it were, "forced into one sack."

Thus the country situated about the mouth of the former river was, on October 31, 1831, overflowed by a storm-wave to a distance of 150 miles from the coast, and 300 native villages with their 10,000 inhabitants were destroyed; and it was visited a second and a third time by cyclones on October 7, 1832, and September 21, 1839. At the mouth of the Hooghly on the 21st of October, 1833, some 10,000 lives were lost in a storm-wave, and on May 21st of the same year, near Coringa, 600 villages, with 50,000 souls, were swept away. In the last-named case the wave rose nine feet higher than the highest point ever before observed, and the barometer suddenly fell all of two inches. During the cyclone of October 5, 1864, at Calcutta, 1,500 square miles of country was overflowed, though the banks of the Hooghly and its tributaries, and the shores of the islands in the mouth of the stream, were protected by dikes eight to ten feet high. But even though these dikes had been sufficiently strong to resist the pressure of the water, still they were far from being sufficiently high. On this occasion the storm-wave rose sixteen and a half feet over the water-mark of the spring-tide, and twenty-seven feet above the mean level of the sea; still, it attained this height only because it entered the river at about high water. The wave was noticed as far as Mehurpore, on the Matabangha. It caused the loss of 50,000 human lives, but the destruction of life would have been far greater had the cyclone occurred at night, and had the people, as at Bacarganch been

surprised in their sleep. While this wave was ascending the Hooghly, and spreading over the neighboring districts, a portion of the same wave seems to have struck the coast near Chittagong, and, having swept along the same, to have overflowed the islands of Shahabazpore and Hattia from the rear. And this is the cause of the fearful devastation it wrought, for we shall not err if we suppose waves coming from two opposite directions to have met at these islands The number of human victims in the catastrophe of 1864 was nearly doubled in consequence of the diseases produced by the multitude of unburied dead bodies, and which carried off 30,000 souls. Hardly four weeks after the Hooghly catastrophe of 1864, namely, on November 5th, the coast at Masulipatam, on the Kistnah—a locality specially adapted for concentrating the force of the storm-wave and intensifying its powers of destruction—was overflowed and 35,000 lives were lost. Three years later, on November 1, 1867, the Calcutta district was again visited; but, fortunately, on this occasion only 1,000 lives were lost, though 30,000 huts of the natives were swept away. But of all the disasters of this kind which have occurred prior to 1876, that of June 6, 1822, was the most appalling and destructive, and the only one to be compared with that of last October. As is shown by Beveridge in his recently-published work on Bacarganch, the cyclone had a very wide track, extending far inland on the east, and beyond Calcutta to the west. The wave which overflowed the mouths of the Ganges and the adjoining coasts fortunately appeared early in the evening, and the people were somewhat prepared for it; nevertheless, 100,000 human beings lost their lives, and an equal number of cattle, and the damage otherwise exceeded 1,000,000 rupees.

Concerning the latest deplorable catastrophe, we possess the following data: Down to 11 P. M. there was no sign of impending danger; before midnight the storm burst suddenly, and without warning, surprising the people in their beds and dwellings. Three storm-waves swept over an area of 3,000 square miles, containing a population of 1,000,000 souls. In a few minutes, 215,000 human beings were swept off by the waters, and there perished. This estimate, however, is probably far too low; for nearly all the officials from whom authentic information might have been obtained themselves perished in the flood, and many villages are known to have lost seventy per cent. of their inhabitants. This is undoubtedly the gravest calamity ever caused by water. Three great islands, and innumerable small ones, were entirely swept by the flood, as also the mainland, over an area of five or six miles in length by about four miles in width. These islands all lie near the mouth of the Meghna, a river formed by the union of the Ganges with the Brahmapootra. The largest of the islands—Dakhin Shahabazpore—is 800 miles in circumference, and had 240,000 inhabitants, while the other two great islands—Hattia and Sundney—had in all about 100,000 inhabi-

tants. The people had only a few minutes to think of their safety, when the wave rose ten to twenty feet above the land. Two hours later the flood began to subside, but not till noon of the following day could the survivors quit their places of refuge in the trees, etc. As luck would have it, the villages are surrounded by groves of cocoanut and palm trees: those who saved themselves did so by taking to the trees. Some took refuge on the house-tops, but the water entered the houses and rose to the roofs, and carried them off to the sea, together with the people upon them. There was hardly a household on the islands, or on the neighboring coast, but had lost several of its members. All the cattle were lost. Boats were swept away, and as wagons on wheels are unknown in that region, all means of communication failed. Nearly all of the civil and police officials perished. The town of Dowluctor was utterly destroyed. The loss in cattle cannot be estimated. The crops suffered greatly, but it is hoped that enough remains to prevent a famine. The entire flooded region looks like a waste. Still the condition of the survivors just after the catastrophe was better than was to have been expected. The farmers of that region are the most thrifty in Bengal; the provisions are mostly kept buried in the ground; hence, though they were damaged by water, they can still be used for food. Wherever Sir R. Temple went he found the people drying grain in the sun. Until harvest-time, the cocoanuts will be of some assistance. Prior to the calamity, the harvest promised to be very bountiful; as it is, it will be a fair one. About sixty relief-stations were established. The official journal says: "Wherever the storm-wave struck, not a third part of the population, it is believed, survives. The islands have only a fourth of their former inhabitants. The odor of the decaying carcasses is intolerable, and a general outbreak of cholera is hourly expected." From an official communication, it appears that there perished in Chittagong during the storm over 3,000 souls, and between October 31st and December 31st, 4,399 persons died of cholera. Since New-Year's cholera has raged fearfully. In the district of Noakholly there died in October 43,544 persons, and in the following three months 30,263. Indeed, with the exception of the islands of Hattia and Sundney, the deaths from cholera everywhere have exceeded those caused by the inundation. On these two islands the number of deaths in October was 34,708; later it was only 7,139.

Thus, in the course of eighty-seven years, half a million of human beings have lost their lives by cyclones, without counting the mortality from pestilence and famine.—*Das Ausland.*

OUR SIX-FOOTED RIVALS.

I.

LET us suppose that, having no previous acquaintance with the subject, we were suddenly informed, on good authority, that there existed in some part of the globe a race of beings who lived in domed habitations, aggregated together so as to form vast and populous cities; that they exercised jurisdiction over the adjoining territory, laid out regular roads, executed tunnels underneath the beds of rivers, stationed guards at the entrance of their towns, carefully removed any offensive matter, maintained a rural police, organized extensive hunting-expeditions, at times even waged war upon neighboring communities, took prisoners and reduced them to a state of slavery; that they not merely stored up provisions with due care, to avoid their decomposition by damp and fermentation, but that they kept cattle, and in some cases even cultivated the soil and gathered in the harvest. We should unquestionably regard these creatures as human beings who had made no small progress in civilization, and should ascribe their actions to reason. If we were then told that they were not men, and they were in some places formidable enemies to man, and had even by their continued molestations caused certain villages to be forsaken by all human occupants, our interest would perhaps be mixed with some little shade of anxiety lest we were here confronted by a race who, under certain eventualities, might contest our claim to the sovereignty of the globe. But when we learn that these wonderful creatures are insects some few lines in length, our curiosity is cooled; we are apt, if duly guided by dominant prepossessions, to declare that the social organization of these beings is not civilization, but at most *quasi*-civilization; that their guiding principle is not reason, but "instinct," or *quasi*-intelligence, or some other of those unmeaning words which are so useful when we wish to shut our eyes to the truth. Yet that ants are really, for good or evil, a power in the earth, and that they seriously interfere with the cultivation and development of some of the most productive regions known, is an established fact. A creature that can lay waste the crops of a province or sack the warehouses of a town has claims upon the notice of the merchant, the political economist, and the statesman, as well as of the naturalist.

Many observers have been struck with the curious mixture of analogies and contrasts presented by the Annulosa and the Vertebrata. These two classes form, beyond any doubt, the two leading subdivisions of the animal kingdom. To them nineteen-twentieths of the population of the dry land, both as regards individuals and species, will be found to belong, and even in the world of waters they are

largely represented. At the head of the Vertebrata stands the order of the Primates, culminating in man. At the head of the Annulosa the corresponding place is taken by the Hymenopterous insects. It is very remarkable—as first pointed out, we believe, by Mr. Darwin—that these two groups of animals made their appearance on the earth simultaneously. But along with this analogy we find a contrast. Man stands alone among the Primates as a socially organized being, possessing a civilization. Among the Hymenoptera the lead is undoubtedly taken by the ants, which, like man, have a brain much more highly developed than that of the neighboring inferior groups. But there is no one species of ant which enjoys a preëminence over its congeners anything at all approaching in its nature and extent to man's superiority over the gorilla or the mias. What may be the cause of this contrast we know not. Perhaps it is merely due to the tendency of the Annulosa to branch out into a scarcely numerable host of forms, while the vertebrate structure, less plastic, lends itself more sparingly to variation. Perhaps, on the other hand, lower human or higher ape forms than any now existing have been extirpated, as the traditions of many ancient nations would seem to admit.

At any rate, while the superiority of the ants as a group to the remaining Hymenoptera, to all other insects, and to the rest of the annulose "sub-kingdom," is undisputed, we are unable to decide which species of ant is elevated above the rest of the Formicide family. Possibly more extended and more systematic observations may settle this interesting question. According to our present knowledge the claims of the agricultural ant, of Western Texas (*Myrmica barbata*), seem, perhaps, the strongest. This species, which has been carefully studied by Dr. Lincecum, for the space of twelve years, is, save man, the only creature which does not depend for its sustenance on the products of the chase or the spontaneous fruits of the earth. As soon as a colony of these ants has become sufficiently numerous they clear a tract of ground, some four or five feet in width, around their city. In this plot all existing plants are eradicated, all stones and rubbish removed, and a peculiar species of grass is sown, the seeds of which resemble very minute grains of rice. The field—for so we must call it—is carefully tended by the ants, kept free from weeds, and guarded against marauding insects. When mature, the crop is reaped and the seeds are carried into the nest. If they are found to be too damp they are carefully carried out, laid in the sunshine till sufficiently dry, and then housed again. This formation of a plot of cleared land—or, as Dr. Lincecum not very happily terms it, a pavement—is a critical point in the career of a young community. Any older and larger city which may lie within some fifty or sixty paces looks upon the step as a *casus belli*, and at once marches its armies to the attack. After a combat, which may be prolonged for days, Providence declares in favor of the largest battalions, and the less numerous community is

exterminated, fighting literally to the last ant. Where a colony is unmolested it increases rapidly in population, and undertakes to lay out roads: one of these, from two to three inches in width, has been traced to a distance of 100 yards from the city. These ants are not very carnivorous, nor do they damage the crops of neighboring farmers. Persons who intrude upon the "pavement" are bitten with great zeal, but otherwise the species may be regarded as harmless. One creature alone they seem to tolerate on their "pavement"—the so-called small black "erratic" ant—which, as Dr. Lincecum conjectures, may be of some use to them, and which is therefore allowed to build its small cities in their immediate neighborhood. If it becomes too numerous, however, it is got rid of, not by open war, but by a course of systematic and yet apparently unintentional annoyance. The agricultural ants suddenly find that it is necessary to raise their pavement and enlarge the base of their city. In carrying out these alterations they literally bury the nests of their neighbors under heaps of the small pellets of soil thrown up by the prairie earth-worms, and continue this process till the erratic ants in sheer despair remove to a quieter spot.

Concerning the government either of the agricultural ants or of other species, our knowledge is of a very negative character. The queens, or rather mothers, of the city are indeed treated with great attention, but their number is quite indefinite, and, unlike female hive-bees, no jealousy exists between them. How their migrations, their wars, their slave-hunts, are decided on, or even how the guards on duty are appointed, and the visiting parties selected who go round to inspect the works, and who sometimes insist on the destruction and rebuilding of any badly-executed portion, we are utterly ignorant. The outer manifestations of ant-life we have to some extent traced; but its inner springs, its directing and controlling powers, have eluded our observation.

It has been remarked, in the *Quarterly Journal of Science*, that ants, unlike man, have solved the problem of the practical organization of communism: this is literally true. In a formicary we can detect no trace of private property; the territory, the buildings, the stores, the booty, exist equally for the benefit of all. Every ant has its wants supplied, and each in turn is prepared to work or to fight for the community as zealously as if the benefit of such toil and peril were to accrue to itself alone. If the principle—so common among men—that there is no harm in robbing or defrauding a municipal body, or the nation at large, crops up in an ant-hill at all, it must evidently be stamped out with an old-fashioned promptitude. But, to understand why the ant has succeeded where man has failed, we must turn to certain fundamental distinctions between human and ant society; or, perhaps, speaking more generally, between the associations of vertebrate and those of annulose animals. A human tribe or na-

tion—and, in like manner, e. g., a community of beavers or of rooks—is formed by the aggregation, not of single individuals, but of groups, each consisting of a male, a female, and their offspring. The social unit among vertebrates, therefore, is the family, whether permanent or temporary, and whether monogamous or polygamous. In numberless cases the family exists without combining with other families to form a nation, but we greatly doubt if there exists a single case of a vertebrate nation not formed of and resolvable into families.

Among the Annulosa this is reversed. The family among them scarcely exists at all. Rarely is the union of the male and the female extended beyond the actual intercourse, all provision for the future young devolving upon the latter alone. Among the rare exceptions to this rule, we may mention the burying-beetle, and some of the dung-beetles, both sexes of whom labor conjointly to find and inter the food in which the eggs are to be deposited. Generally speaking, moreover, the young insect never knows—never even sees—its parents, who in most cases have died before it has emerged from the egg. Among non-social insects the earwig and a few other Orthoptera form the chief exceptions. Where a regularly organized society, a nation, or tribe, exists among annulose animals, it is not formed by the coalescence of families to a higher unity. The family, if it can be said to exist at all, is conterminous and identical with the nation. This absence of a something whose claims are felt by all ordinary men to be stronger than those of the state has rendered the successful organization of the "commune" feasible among ants, and among other social Hymenoptera, such as bees, wasps, etc. With them the state has no rival, and absorbs all the energies which in human society the individual devotes to the interests of his family. We thus see that theorists on social reform have been, from their own point of view, logically consistent in attacking the institution of marriage and the whole system of domestic life: they have sought to abolish the great impediment to the commune, and to approximate man to the condition of our six-footed rivals, and to constitute society not as heretofore of molecules, but of atoms.

But it is not enough to show that the failure of communism among mankind and its success among certain Hymenopterous insects are due to the existence and the power of the family in the former case, and to its absence in the latter. We have yet to inquire into the wherefore of so important a distinction. Vertebrate society, where it exists at all, is founded on family life, because every vertebrate animal is sexual, and as such is attracted to some individual of the opposite sex by the strongest instinct of its nature, that of self-preservation alone excepted. Invertebrate society, where it exists in perfection, as among the Hymenoptera, is not formed by a union of families, because the great majority of Hymenopterous individuals (in the social species) are non-sexual, neuter, incapable of any private or domestic attach-

ments, and devoted to the community alone. To attempt, without the existence of such an order, to introduce the social arrangements of the ant—i. e., communism—among mankind is as futile and as irrational as the endeavor to fly without wings: the very primary conditions for success are wanting.

It may not be amiss to examine a little further in the same direction. Among men there is a great diversity both in intellect and in energy. The more highly-endowed individual, if he does not leave his children in a better position, materially speaking, is likely to transmit to them his own personal superiority. In this manner the theoretical equality assumed as one of the bases of communism is in practice annihilated. Among ants nothing of this kind can prevail. The workers and the fighters are sexless. If any individual is superior to its fellows in strength or in intelligence—and we have every reason to believe that such must be the case—it has no posterity to whom its acquisitions could be bequeathed or its personal superiority handed down. Hence the formation of an aristocracy is impossible, and whatever benefit may result from the labors of such an exceptional individual flows to the entire community. In the converse manner the formation of a pariah, a criminal, or a pauper class, is frustrated, and the public is not burdened with useless or dangerous existences.

It is indisputable that this arrangement, joined to the brief term of insect-life, must greatly retard the progress of the ant in civilization. It has been remarked that were human life longer our development in knowledge and in the arts would be much more rapid. Take our present condition: by the time a man has completed his education, general and special—has fully developed his own mental faculties and mastered the position of the subject he has selected—he will be rarely less than five-and-twenty years of age. By the time he is fifty, as a rule, his power of origination begins to decline, and the remainder of his life is spent more in completing and rounding off the work of his younger days than in making fresh inroads into the unknown. Did our full vigor of intellect extend over a century, instead of over a fourth of that duration, we should undoubtedly effect much more. On the other hand, a shortening of our time of activity would have a powerfully retarding effect on the career of discovery and invention. Can we, then, wonder if the short-lived ant and bee sometimes appear to us stationary in their civilization? But this very brevity of the career of each individual acts decidedly in favor of the preservation of social equality. If either ant or man is disposed to rise or to fall, then the shorter the time during which such rise or fall is possible the better will the uniform level of society be preserved. To prevent misunderstanding we must remark that castes with a corresponding difference of duties, and, according to some authorities, with a diversity of honor also, do occur in the ant-hill; but within each caste all are on an exactly equal footing.

If we compare the zoölogical rank of our "six-footed rivals" with our own, we must, from one point of view, concede them a higher position. The more perfectly developed is any animal the more do we find it possessed of an especial organ for the discharge of every function. In like manner it may be contended that, as a species rises in the scale of being, duties once indiscriminately performed by all the species are assigned to distinct individuals. Among the humbler groups of the animal kingdom the whole reproductive task is performed by all members of the species. In other words, hermaphroditism prevails. As we ascend to higher groups the sexes are separated, and the species becomes dimorphous. This arrangement prevails among all vertebrate animals, and among a large majority of annulose species. We find here already, however, one of those contrasts which so often prevail between these two great series of beings. Among vertebrates, and especially in mankind, the function of the female sex seems limited to the nurture—intra- and extra-uterine—of the young. Were man immortal and non-reproductive, woman's *raison d'être* would disappear. Among Annulosa the very reverse holds good; the females are as a rule larger, stronger, and more long-lived, while the task of the male seems limited to the fecundation of the ova. This being once performed, his part is played. Among butterflies, moths, and ants, his death speedily follows, while among spiders he is generally killed and devoured by his better-half. This predominance of the female sex seems to prepare the way for the phenomenon which we recognize among the social Hymenoptera. Here the species become no longer dimorphous, but polymorphous. In other words, in addition to the males and females, whose task is now exclusively confined to the mere function of reproduction, there are, as we have seen, one or more forms of females, sexually abortive, but so developed in other respects as to form the castes of workers and fighters, upon whom the real government of the ant-hill devolves, who provide for its enlargement, well-being, and defense.

It may, we think, be legitimately contended that the development of a distinct working order is a step in advance similar to that taken by the distribution of the sexual functions among two different individuals—that the polymorphic species is higher than the dimorphic, just as the dimorphic is higher than the monomorphic.

Of the development of a neuter order among vertebrate animals, and especially among mankind, we know nothing which can be fairly called a trace. But, in comparing the two civilizations, that of man and that of the ant, we must be struck with the fact that the former has from time to time imitated this peculiar feature. The attempts, however, whether made by the devotion of certain classes to celibacy or by actual emasculation, have been as unsuccessful as the sham elephants of Semiramis. Celibates retaining the sexual appetite, but

deprived of its legitimate exercise, have always been a disturbing force in society. On the other hand, emasculation, instead of—as might have been perhaps, *a priori*, anticipated—increasing the powers of body and mind, enfeebles both. What would be the moral and social effects of the appearance of a neutral form of the human species analogous to the working bee or ant it is impossible to foresee; but we may venture to surmise that they would not be entirely desirable.[1]

It may be suggested that the institution of caste among so many human races is an adumbration of the natural castes existing among social insects, each devoted to some especial function.

The remarkable intelligence of ants has from very early ages made a profound impression on man. Cicero considered them possessed of "mind, reason, and memory."[2] To the present day those who watch the formicary, not in order to defend prepossessions, but to arrive at truth, come to the same conclusion, unpopular though it may be. We sometimes wonder whether ants, like men, consider themselves the sole reasonable beings on the globe, prove their position by sound *a priori* arguments, and accuse those who take a different view of "skepticism" or "agnosticism."

When it is no longer possible to meet with a flat denial all instances of correct inferences drawn and of happy contrivances adopted by brutes in general and by ants in particular, the writers who still claim reason as the exclusive prerogative of man bring forward a curious objection: they urge that we should likewise collect proofs of animal folly and stupidity, and seem to think that these latter instances would nullify any conclusion that might be drawn from the former. That instances are numerous where some animal fails to draw an inference—very obvious, in our view—or to adopt some very simple expedient, we do not deny, and that their conduct hence seems strangely checkered, we admit. What, e. g., can seem more inconsistent than the following cases? Sir John Lubbock, to test the intelligence of ants, placed a strip of paper so as to serve as a bridge or ladder for some ants which were carrying their pupæ by a very roundabout way. The slip was, however, purposely left short of its destination by some small fraction of an inch. It would have been very easy for the ants either to have dropped themselves and their burden down this short distance, or to have handed the pupæ to the other ants below, or to have piled up a small amount of earth from below, so as to meet the slip of paper, and thus make the descending road continuous. They adopted, however, none of these expedients, but continued to travel the roundabout way.

[1] It is very remarkable that among the Termites, which, though improperly called "white ants," belong to a different order of insects, neuters exist. These, however, do not appear to be imperfectly developed females. It would thus seem that among insects social organization necessitates a class of sexless individuals.

[2] "Mens, ratio, et memoria."

On the other hand, Mr. Tennant tells us that *Formica smaragdina*, in forming its dwellings by cementing together the leaves of growing trees, adopts the following method: A line of ants, standing along the edge of one leaf, seize hold of another, and bring its margin in contact with the one on which they are posted. They then hold both together with their mandibles, while their companions glue them fast with a kind of adhesive paper which they prepare. If the two leaves are so far apart that a single ant cannot reach from one to another, they form chains with their bodies to span over the gap. The same author also informs us that certain Ceylonese ants, when carrying sand or dry earth for the construction of their nests, glue several grains together so as to form a lump as large as they can carry, and thus economize time and labor.

Mr. Belt, in his "Naturalist in Nicaragua" (page 27), gives the following account of the manner in which the *Ecitons*, or foraging ants of Central and South America, deal with what may be called engineering difficulties: "I once saw a wide column trying to pass along a crumbling, nearly perpendicular slope. They would have got very slowly over it, and many of them would have fallen, but a number having secured their hold and reaching to each other remained stationary, and over them the main column passed. Another time they were crossing a water-course along a small branch, not thicker than a goose-quill. They widened this natural bridge to three times its width, by a number of ants clinging to it and to each other on each side, over which the column passed three or four deep; whereas, except for this expedient, they would have had to pass over in single file, and treble the time would have been consumed."

Again, in *Eciton legionis*, according to Mr. Bates, when digging mines to get at another species of ant whose nests they were attacking, the workers were divided into parties, "one set excavating and another set carrying away the grains of earth. When the shafts became rather deep the mining parties had to climb up the sides each time they wished to cast out a pellet of earth, but their work was lightened for them by comrades who stationed themselves at the mouth of the shaft and relieved them of their burdens, carrying the particles, with an appearance of foresight which quite staggered me, a sufficient distance from the edge of the hole to prevent them from rolling in again."

What, then, are we to learn from these somewhat inconsistent cases? Are we to conclude that Sir John Lubbock, Mr. Belt, Mr. Bates, and Mr. Tennant, must be careless and incompetent observers? Assuredly not. Are we to believe that ants are stupid, irrational creatures, and that when they do anything right it must be regarded as an accident or ascribed to that convenient phantom, instinct? Still less: the well-established cases which are on record agree badly with either of these suppositions. The true explanation of the diffi-

culty is that, like all finite intelligences, ants are not equally wise on all occasions. Sometimes they hit upon the best expedient for evading or overcoming an obstacle, but sometimes, under circumstances not more complicated, they fail. This is doubtless the case with man himself. If contemplated by some being endowed with higher reasoning powers, would he not be pronounced a most curiously inconsistent mixture of sagacity and stupidity, now solving problems of no small difficulty, and now standing helpless in presence of others even more simple? That such is in reality the case with man is proved by the history of discoveries, and of their reception. Do we not always say when we hear of any great step, whether in scientific theory or in the practical arts, "How simple, how natural!" Yet, simple and natural as it is, all sorts and conditions of men lived for centuries without opening their eyes to it. To those who, on the score of incidental blunders and stupidities, deny the rationality of animals, we would hold up the ever-memorable "egg" of Columbus, and exclaim, "What, gentlemen, do you expect the ant to be be more uniformly and consistently intelligent than your erudite selves?"

Concerning the language of ants no small diversity of opinion has prevailed; but among actual observers the general conclusion is that these tiny creatures can impart to each other information of a very definite character, and not merely general signals, such as those of alarm. It has been found that ants fetched by a messenger for some especial purpose seem, when they arrive at the spot, to have some knowledge of the task which is awaiting them, and set about it at once without any preliminary investigation. The cases which we quote elsewhere from Mr. Belt are very conclusive on this point. In order to decide whether ants are really fetched to assist in tasks beyond the strength of any one of their number, Sir John Lubbock instituted a very interesting and decisive experiment. It is well known that if the larvæ of ants are taken out of the nest, the workers never rest till they have fetched them back. Sir John Lubbock took a number of larvæ out of his experimental formicary, and placed them aside in two parcels very unequal in number. Each of these lots was soon discovered by an ant, who at once fell to work to carry the larvæ back to the nest, and was soon joined by others, eager to assist. The observer reasoned thus: If these ants have come to the spot by accident, it is probable that the number who arrive at each lot will be approximately equal. On the other hand, if they are intentionally fetched to assist in removing the larvæ, the number in each case will most likely bear some proportion to the amount of work to be done. The result was, that the large heap of larvæ was visited by about three times as many ants as the small one. Hence the inference is plain that ants can call assistance to any task in which they are engaged, that they can form some estimate of the amount of labor that will be required, and can make their views in some manner known to their

companions. The manner in which, when on the march, they are directed by their officers, and the promptitude and precision with which a column is sent out to seize any booty indicated by scouting-parties, show likewise a completeness and precision of language very different from anything we observe in quadrupeds and birds.

But as to the nature of this language, which Mr. Belt rightly calls "wonderful," we are as yet very much in the dark. Sounds audible to our ears they scarcely can be said to emit. Their principal organs of speech are doubtless the antennæ: with these, when seeking to communicate intelligence, they touch each other in a variety of ways. There can be no doubt that, with organs so flexible and so sensitive, an interchange not merely of emotions but of ideas must be easy.

But there is another channel of communication which deserves to be carefully investigated. We know that the language of vertebrates, or at least of their higher sections, turns on the production or recognition of sounds. What if the language of social insects should be found to depend, in part at least, on the production and recognition of odors? We have already full proof that their sense of smell is developed to a degree of acuteness and delicacy which utterly passes our conceptions of possibility, and to which the scent of the keenest hound presents but a very faint approximation. Collectors of Lepidoptera are well aware that if a virgin female moth of certain species is inclosed in a box, males of the same species will make their appearance from distances which may be relatively pronounced prodigious. As soon, however, as the decoy has been fecundated, this attraction ceases. This is only one among the many phenomena which testify to the wonderful olfactory powers of insects. So much, then, for the recognition of odors. Nor is their production among insects a matter open to doubt. Scents, distinctly perceptible even to our duller organs, are given off by many. The pleasant odor of the musk-beetle, and the offensive smells of the ladybirds, the common ground-beetles, the oil-beetles, the Spanish fly, and the "devil's coach-horse"—hence technically named *Gœrius olens*—are known to every tyro in entomology. The next question is, Are these odors at all under the control of the insect, and capable of being produced, suppressed, or modified at will? We have noticed many instances where the odors of insects became more intense under the influence of anger or alarm. A peculiarly pungent odor is said to issue from a beehive if the inmates are becoming excited.

The possibility of a scent-language among insects must therefore be conceded. Mr. Belt thinks that the *Ecitons* mark out a track which is to be followed by their comrades by imparting to it some peculiar odor. He says: "At one point I noticed a sort of assembly of about a dozen individuals that appeared in consultation. Suddenly one ant left the conclave, and ran with great speed up the perpendicular face of the cutting without stopping. It was followed by others, which,

however, did not keep straight on like the first, but ran a short way, then returned, and then again followed a little farther than the first time. They were evidently scenting the trail of the pioneer, and making it permanently recognizable. These ants followed the exact line taken by the first one, though it was far out of sight. Wherever it had made a slight *détour*, they did so likewise. I scraped with my knife a small portion of the clay on the trail, and the ants were completely at fault for a time which way to go. Those ascending and those descending stopped at the scraped portion, and made short circuits until they hit the scented trail again, when all their hesitation vanished, and they ran up and down it with the greatest confidence."

That among groups like the *Ecitons*, in which the sense of sight is imperfect, or even totally wanting, enhanced delicacy of scent and touch must be required in compensation, may be taken as self-evident. With the language of ants, and especially with a possible scent-language, is connected the faculty by means of which denizens of the same city recognize each other under circumstances of great difficulty. In the battles which take place between two nations of the same species, how, save by scent, do the tiny warriors distinguish friend from foe? We are told by some older observers that if an ant is taken from the nest, and restored after the lapse of several months, it is at once received by its companions and caressed, while a stranger ant introduced at the same time is rejected, and generally killed. To a great extent this has been confirmed by recent investigators. The returned exile was not indeed caressed, but was quietly allowed to enter the nest, while a stranger was at once greeted with hostile demonstrations. It has been maintained that this power of recognition is destroyed by water, and that ants will treat a comrade as an enemy if he has received a drenching. This, however, is evidently a mistake. To prevent rain from penetrating into the nests of the agricultural ant, the guards block up the doorways with their bodies, and are often drowned at their posts. But their companions are not thereby prevented from recognizing them, as they try to bring the dead bodies to life.—*Quarterly Journal of Science.*

HISTORY OF THE DYNAMICAL THEORY OF HEAT.[1]

By PORTER POINIER.

I.

A RECAPITULATION of the various conjectures which have been advanced in explanation of so ever-familiar a sensation as that of warmth or heat, would neither prove particularly feasible nor interesting; for doubtless during the vast period of time which has elapsed

[1] Introduction to an unpublished work on Thermo-Dynamics.

since the enunciation of atomic doctrines by the old Greek philosophers—and from their great suggestiveness—the speculations of reflective minds have wandered over wellnigh every imaginable hypothesis, and approximated with greater or less minuteness to the views which are admitted now, and which we think to be supported by experiment. Thus, as a case in point, we may refer to Galileo,[1] whose resource of observation could have scarcely been superior to Archimedes's, and who would seem to have conceived of an increase of heat as only a more elementary condition of material substance, in which the more or less considerable destruction of molecular bonds allowed the individual particles of a body to move among themselves with a more unconstrained vibration.

But very few among the countless suppositions which we might thus succeed in raking up, however curious or predictive in themselves, would have the slightest bearing on our present subject. Developed only to the extent demanded by the superiority of the scholastic mind, they would be found in general mere arbitrary, whimsical assertions; untried and unsupported by critically-devised experiments. With the reformation of philosophy does our historical sketch then properly begin, and, moreover, with Lord Bacon as its founder; for, in illustrating the proper method of establishing a philosophical doctrine, he forever identified himself with the dynamic theory, by showing that the most comprehensive explanations were afforded by considering heat to be an intestine motion of the constituent particles of a body. Systematically reviewing the known properties and effects of heat—the only practicable course open to him—he concluded in the following memorable and oft-quoted passages:[2]

"Atque hæc sit Prima Vindemiatio, sive Interpretatio inchoata de Forma Calidi, facta per Permissionem Intellectus.

"Ex Vindemiatione autem ista Prima, Forma sive definitio vera Caloris (ejus qui est in ordine ad universum), non relativus tantummodo ad sensum talis est, brevi verborum complexu: *Calor est motus expansivus, cohibitus, et nitens per partes minores.*"

We find, therefore, in older writings, the first considerable support of this doctrine attributed to Bacon; and it must be conceded that to the power and vividness with which he portrayed his conception of this agent was due in a great measure the tenacity with which it was afterward, from time to time, brought forward and upheld.

The subsequent supporters of this view, though not perhaps most numerous, comprised by far the most distinguished and profound philosophers of their time, their writings furnishing many remarkable anticipations of heat-theory as now received.

[1] "Opere di Galileo Galilei," tom. ii., p. 505, *et seq.*

[2] "Novum Organum," lib. sec., aphorism 20. Spedding and Ellis's translation, vol. iv., p. 154.

Newton,[1] quite singularly, while rejecting the wave-theory of light, gave his assent to the analogous ideas respecting heat; and, in so far as we may judge, conceived the warmth excited in a body when exposed to light or radiant heat to be due to the little shocks which luminous or radiant material might produce in it.

Huyghens, Hooke, Locke, and Cavendish, among others, were also favorably inclined to the Baconian view;[2] the works of Hooke particularly containing many and strong expositions of the vibratory notion, and his comments on the mechanical and chemical production of heat being urged often with as great clearness, and as subtile a perception of occult natural causes, as any which we now possess.[3]

But the adaptation of the known "laws of motion" to these operations, whereby heat might in many instances have been directly correlated to the energy expended in producing it, was not until long after definitely proposed; and though, in 1744, Boyle,[4] perhaps as intelligently as any one before him, had attributed the heating of a hammered body to the transfer of the "motion" of the hammer to the ultimate particles of the body struck, yet the idea of the indestructibility of energy in all cases, and of course, therefore, in the mechanical excitation of heat, would not seem to have been expressly urged before the time of Rumford and Sir Humphry Davy.

In the mean while, however, a new doctrine was brought forth, assigning to heat a material existence and chemical properties. First

[1] Newton's "Optice," queries at the end of treatise, especially Nos. 6, 8, 12, 18, 23, and 31.

[2] The ideas of Huyghens on this point would seem to have resembled somewhat those of Galileo, already quoted. *See* "Exposé de la Situation de la Mécanique Appliquée," par Combes, etc., p. 200. Paris, 1867. And Locke quite uniformly made use of Bacon's hypothesis. *See* particularly his essay on the "Conduct of the Human Understanding, Elements of Natural Philosophy," chap. xi., where he says:

"Heat is a very brisk agitation of the insensible parts of the object which produces in us that sensation whence we denominate the object hot; so what in our sensation is heat, in the object is nothing but motion. . . .

"On the other side, the utmost degree of cold is the cessation of that motion of the insensible particles which to our touch is heat."

[3] Hooke's "Micrographia," obs. xvi., 12th particular. "Posthumous Works," p. 49. "Lectures on Light," p. 116.

[4] "And now I speak of striking an iron with a hammer, I am put in mind of an operation that seems to contradict, but does indeed confirm our theory: namely, that if a somewhat longer nail be driven by a hammer into a plank or piece of wood, it will receive divers strokes on the head before it grow hot; but when it is driven to the head, so that it can go no further, a few strokes will suffice to give it a considerable heat; for while at every blow of the hammer the nail enters further and further into the wood, the motion that is produced is chiefly progressive, and is of the whole nail tending one way; whereas, when that motion is stopped, then the impulse given by the stroke being unable either to drive the nail further on or destroy its entireness, must be spent in making a various, vehement, and intestine commotion of the parts among themselves, and in such an one we formerly observed the nature of heat to consist."—(Boyle, "On the Mechanical Origin of Heat and Cold," "Complete Works," vol. iv., p. 236, *et seq.*, exp. vi.)

advocated, it is thought, by Boerhaave[1] and Lémery,[2] it received in 1787 the unrestricted name "caloric" from the French Academy.

According to these hypothetic notions, singularly cramped and superficial, as compared with the more fruitful ideas of Bacon, caloric, or the matter of heat, was thought to be a highly-elastic, imponderable fluid; which, distributed among the constituent molecules of bodies, in quantities varying with the temperature in the same, or the "capacity" in different kinds of substance, occasioned all the known phenomena of heat: the sensation, through an occult property of its own; expansion and repulsion, by the entrance of its own substance among the molecules of the bodies heated; a change of state whenever the effective action of any particular set of molecular forces should thus happen to be overcome; and in radiation passing from one body to another with vast swiftness. Being, moreover, an unchangeable material, a definite created quantity of it was considered to exist at all times in the universe.

The idea of a substance unaffected by the force of gravity did not appear so very improbable in those days, while the then frequent separation of some new or more elementary gas, and the astonishing effects directly traceable to their action, quite naturally suggested an analogous causation in thermal phenomena.

The discovery by Black, of latent heat,[3] seemed also to supply the necessary induction for its quantitative treatment; so that toward the beginning of the present century, and upon chemical considerations merely, the hypothesis of caloric had succeeded in supplanting quite effectually the ideas of Bacon.

The explanations which it gave of the mechanical excitation of heat were not so plausible, however; certain phenomena appearing utterly incongruous with the idea of an unalterable material supply of heat-substance, and its continued production of friction—a phenomenon which has been since said to have furnished the key to the whole science of thermo-dynamics—serving eventually to completely overturn it. In explaining such phenomena, therefore, those who still chose the material hypothesis were compelled to overlook some very significant objections; while, still supposing it to be a vibratory mo-

[1] "De Igne, Elementa Chemiæ," i., 116.

[2] "Sur la Matière du Feu," "Histoire et Mémoires de l'Ac. Par.," 1709, pp. 6, 400.

[3] We know, however, that these discoveries did not fail to be correctly interpreted at the time, for Cavendish, in a foot-note to some "Observations on Mr. Hutchinson's Experiments," etc., "Philosophical Transactions," 1783, p. 312, remarked:

"I am informed that Dr. Black explains the above-mentioned phenomena in the same manner; only instead of using the expression, 'heat is generated or produced,' he says, 'latent heat is evolved or set free;' but as this expression relates to an hypothesis depending on the supposition that the heat of bodies is owing to their containing more or less of a substance called the matter of heat, and as I think Sir Isaac Newton's opinion, that heat consists in the internal motion of the particles of bodies, much the most probable, I choose to use the expression 'heat is generated.'"

tion, the additional phenomena of latent or specific heats were not at all irreconcilable or difficult of explanation.

Thus Lavoisier and Laplace, in their famous "Mémoire sur la Chaleur" of 1780, though still retaining and defending the ideas of caloric, admitted the frictional excitation of heat to be "favorable" to the dynamical hypothesis. But it is, on the other hand, to be remembered that the earlier experiments devoted to the study of this point had been by no means unmistakable in their indications, directed as they had been rather to the detection of some suspected influence of the rubbing surfaces than to the investigation of any possible relation between the heat produced and the energy expended in producing it.

The material hypothesis was, therefore, the prevailing one, when about the year 1797 Count Rumford,[1] while engaged in superintending the construction of cannon at the military arsenal at Munich, became impressed by the considerable generation of heat accompanying their boring. And as he thought upon the explanation of the phenomenon consistent with the then prevailing ideas as to the intimate nature of heat, it seemed to him impossible that an apparently *unlimited* supply of any substance could be separated from so inconsiderable a quantity of borings. The doubt increased when, upon making the determination, he found the specific heat of this *débris* to be the same, apparently, as that of the mass of metal from which it had been separated: for in some obscure manner the "capacity" for heat of any body, or the total quantity of it which it might hold in any particular state, was considered to be intimately connected with, if not entirely defined by, its specific heat.

But, though he quoted this experiment as sufficiently conclusive that the heat set free by friction could not have been produced at the expense of any caloric latent in the metal, he undertook the following more elaborate investigation to determine all the circumstances which might possibly exert an influence on its production: and it appears, both from his method of procedure and the arguments with which he supplemented his results, that he had fully comprehended the philosophical consequences of each rival theory.

In view of the preëminent importance of these first conclusive and well-understood experiments, both with respect to the establishment of the dynamic theory upon an experimental basis, and the undoubted claim of their author to be considered as its founder, we here give as detailed an account of his investigations as may be thought admissible in a work intended merely for didactic purposes; and we conceive a full statement upon this most important point to be the more desirable, from the fact that the completeness with which he then demolished the material hypothesis, and the maturity of his views respecting the dynamical nature of heat, do not of late seem to

[1] "Inquiry concerning the Source of the Heat which is excited by Friction," "Philosophical Transactions," 1798, p. 80. "Complete Works," Am. Ac. ed., p. 400.

have gained the unqualified recognition which they most certainly deserve.

Taking the casting of a brass cannon, solid and rough as it came from the foundery, and with the cylindrical mass of metal *a* (Fig. 1), called the *verlorner Kopf*, still adhering to the muzzle, Rumford caused to be turned upon the superfluous end a smaller cylinder, *b* (Fig. 2),

Fig. 1.

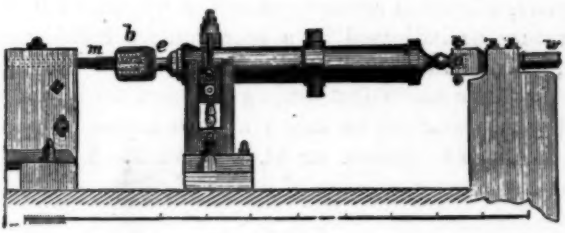


Fig. 2.

7¾ inches in diameter and 9.8 inches long, and which remained connected to the cannon proper by the neck, *e*, 2.5 in diameter and 3.8 inches long.

The whole mass being then secured in the apparatus used for boring (Fig. 2), a cavity 7.2 inches long and 3.7 in diameter was bored in *b*, in the direction of its axis, so that a metal bottom, 2.6 inches thick, remained between the borer and the neck. In this also a small round hole, *c d* (Fig. 3), was radially bored for the insertion of a thermometer. The cylinder, neck, etc., are represented upon a somewhat larger scale in Fig. 3.

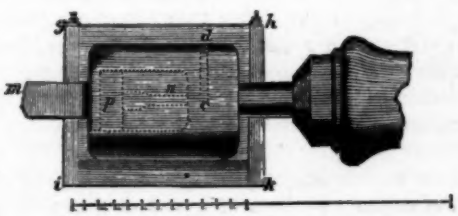


Fig. 3.

The borer used to create friction upon this metallic bottom was a flat piece of hardened steel, 0.63 inch in thickness, four inches long, and nearly as wide as the cylindrical bore in which it turned, 3½ inches; so that the area of contact with the bottom was about 2.33 square inches. This borer was securely held in place against the bot-

tom of the cylinder, and kept from turning by an iron bar, *m*; and thus disposed for the experiment the apparatus is represented in Fig. 2.

In Rumford's first determination the borer was forced against the bottom with a pressure of about 10,000 pounds, and the cylinder was rotated at the rate of thirty-two turns in a minute, by the labor of two horses. To prevent also as far as possible any loss of heat by radiation, the exposed parts were protected by thick coverings of flannel.

At the beginning of the experiment the temperature throughout, as well as that of the surrounding air, was 60° Fahr.; at the end of thirty minutes, when 960 revolutions of the cylinder had been made, the temperature, as indicated by a thermometer introduced into the small hole, had risen to 130°.

Collecting the metallic dust—or, as he described it, scaly matter—which had been detached, he found upon a careful weighing that it amounted to but 837 grains, or 54.2 grammes. Its inadequacy to account for the large excitation of heat fully impressed him, and he exclaims:

"Is it possible that the very considerable quantity of heat that was produced in this experiment (a quantity which actually raised the temperature of above 113 pounds of gun-metal at least 70° of Fahrenheit's thermometer, and which, of course, would have been capable of melting six pounds and a half of ice, or of causing nearly five pounds of ice-cold water to boil) could have been furnished by so inconsiderable a quantity of metallic dust, and this merely in consequence of *a change* of its capacity for heat?

"As the weight of this dust (837 grains, Troy) amounted to no more than $\frac{1}{113}$ part of that of the cylinder, it must have lost no less than 948° of heat, to have been able to raise the temperature of the cylinder 1°; and consequently it must have given off 66,360° of heat to have produced the effects which were actually found to have been produced in the experiment!

"But without insisting on the improbability of this supposition, we have only to recollect that from the results of actual and decisive experiments, made for the express purpose of ascertaining that fact, the capacity for heat of the metal of which great guns are cast *is not sensibly changed* by being reduced to the form of metallic chips in the operation of boring cannon; and there does not seem to be any reason to think that it can be much changed, if it be changed at all, in being reduced to much smaller pieces by means of a borer that is less sharp.

"If the heat, or any considerable part of it, were produced in consequence of a change in the capacity for heat of a part of the metal of the cylinder, as such change would only be *superficial*, the cylinder would by degrees be *exhausted*; or the quantities of heat produced in any given short space of time would be found to diminish gradually in successive experiments. To find out if this really happened or not, I repeated the last-mentioned experiment several times with the utmost care; but I did not discover the smallest sign of exhaustion in the metal, notwithstanding the large quantities of heat actually given off.

"Finding so much reason to conclude that the heat generated in these ex-

periments, or *excited*, as I would rather choose to express it, was not furnished *at the expense of the latent heat*, or *combined caloric* of the metal, I pushed my inquiries a step farther, and endeavored to find out whether the air did, or did not, contribute anything in the generation of it."

In this, his Experiment No. 2, the only modification consisted in fitting the steel borer with an air-tight piston, packed with oiled leather, by which any circulation of air from without to the interior was prevented. But in the use of this device the oiled leather itself, by its friction with the sides of the borer, produced considerable heat, so that, to obviate any possible objection as to this point, Rumford had recourse to his third and most celebrated experiment.

In this, the friction cylinder was made to rotate in a water-tight box, which, being filled with water, completely submerged all the heat-producing parts. Here, therefore, the only supply of caloric, if any, lay in the water, which itself was to be heated by the friction; for had any caloric been abstracted by the heated water from the ambient air, there would have necessarily been a flow of heat from a cool body to a warmer, which every one admitted to be contrary to experience. The apparatus, therefore, having been arranged, the box was filled with water at the temperature of 60° Fahr., and the machinery put in motion.

With reference to what followed, Rumford remarked:

"The result of this beautiful experiment was very striking, and the pleasure it afforded me amply repaid me for all the trouble I had had in contriving and arranging the complicated machinery used in making it.

"The cylinder, revolving at the rate of about thirty-two times in a minute, had been in motion but a short time, when I perceived, by putting my hand into the water and touching the outside of the cylinder, that heat was generated; and it was not long before the water which surrounded the cylinder began to be sensibly warm.

"At the end of one hour I found, by plunging a thermometer into the water in the box (the quantity of which fluid amounted to 18.77 pounds, avoirdupois, or two and a quarter wine-gallons), that its temperature had been raised no less than 47°; being now 107° of Fahrenheit's scale.

"When thirty minutes more had elapsed, or one hour and thirty minutes after the machinery had been put in motion, the heat of the water in the box was 142°.

"At the end of two hours, reckoning from the beginning of the experiment, the temperature of the water was found to be raised to 178°.

"At two hours twenty minutes it was at 200°; and at two hours thirty minutes it ACTUALLY BOILED!

"The quantity of heat excited and accumulated in this experiment was very considerable; for, not only the water in the box, but also the box itself (which weighed 15¼ pounds), and the hollow metallic cylinder, and that part of the iron bar which, being situated within the cavity of the box, was immersed in the water, were heated 150° Fahr., namely, from 60° (which was the temperature of the water and of the machinery at the beginning of the experiment) to 210°, the heat of boiling water at Munich."

The total quantity of heat generated may be estimated with some considerable degree of precision as follows:

	Quantity of ice-cold water which, with the given quantity of heat, might have been heated 180°, or made to boil. In avoirdupois weight. lbs.
"Of the heat excited there appears to have been actually accumulated:	
"In the water contained in the wooden box, 18¾ pounds, avoirdupois, heated 150°, namely, from 60° to 100° Fahr. . . .	15.2
"In 113.13 pounds of gun-metal (the hollow cylinder), heated 150°; and, as the capacity for heat of this metal is to that of water as 0.1100 to 1.0000, this quantity of heat would have heated 12½ pounds of water the same number of degrees	10.37
"In 36.75 cubic inches of iron (being that part of the iron bar to which the borer was fixed which entered the box), heated 150°; which may be reckoned equal in capacity for heat to 1.21 pound of water . . .	1.01
"N. B.—No estimate is here made of the heat accumulated in the wooden box, nor of that dispersed during the experiment.	
"Total quantity of ice-cold water which, with the heat actually generated by friction, and accumulated in two hours and thirty minutes, might have been heated 180°, or made to boil	26.58

"As the machinery used in this experiment could easily be carried round by the force of one horse (though, to render the work lighter, two horses were actually employed in doing it), these computations show further how large a quantity of heat might be produced, by proper mechanical contrivance, merely by the strength of a horse, without either fire, light, combustion, or chemical decomposition; and, in a case of necessity, the heat thus produced might be used in cooking victuals.

"But no circumstances can be imagined in which this method of procuring heat would not be disadvantageous; for more heat might be obtained by using the fodder necessary for the support of a horse as fuel. . . .

"By meditating on the results of all these experiments, we are naturally brought to that great question which has so often been the subject of speculation among philosophers, namely:

"What is heat? Is there any such thing as an *igneous fluid?* Is there anything that can with propriety be called *caloric?*

"We have seen that a very considerable quantity of heat may be excited in the friction of two metallic surfaces, and given off in a constant stream or flux *in all directions* without interruption or intermission, and without any signs of diminution or exhaustion.

"Whence came the heat which was continually given off in this manner in the foregoing experiments? Was it furnished by the small particles of metal, detached from the larger solid masses, on their being rubbed together? This, as we have already seen, could not possibly have been the case.

"Was it furnished by the air? This could not have been the case; for, in three of the experiments, the machinery being kept immersed in water, the access of the air of the atmosphere was completely prevented.

"Was it furnished by the water which surrounded the machinery? That this could not have been the case is evident: 1. Because this water was continually *receiving heat* from the machinery, and could not at the same time be *giving to* and *receiving heat from* the same body; and, 2. Because there was no chemical decomposition of any part of this water. Had any such decomposition taken place (which, indeed, could not reasonably have been expected), one of its

component elastic fluids (most probably inflammable air) must at the same time have been set at liberty, and, in making its escape into the atmosphere, would have been detected; but, though I frequently examined the water to see if any air-bubbles rose up through it, and had even made preparations for catching them, in order to examine them, if any should appear, I could perceive none; nor was there any sign of decomposition of any kind whatever, or other chemical process, going on in the water.

"Is it possible that the heat could have been supplied by means of the iron bar, to the end of which the blunt steel borer was fixed, or by the small neck of gun-metal by which the hollow cylinder was united to the cannon? These suppositions appear more improbable even than either of those before mentioned; for heat was continually going off, or *out of the machinery*, by both these passages, during the whole time the experiment lasted.

"And, in reasoning on this subject, we must not forget to consider that most remarkable circumstance, that the source of the heat generated by friction, in these experiments, appeared evidently to be *inexhaustible.*

"It is hardly necessary to add that anything which any *insulated* body, or system of bodies, can continue to furnish *without limitation*, cannot possibly be *a material substance;* and it appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in the manner the heat was excited and communicated in these experiments, except it be motion."

From this quotation we see, then, that Rumford, with a sagacity indeed consummate, had seized upon the most notable circumstance presented by these experiments, against the materiality of heat. Italicizing the word inexhaustible—a far more significant proceeding than the use of any acids would have been—he showed most incontestably that, to still further reconcile the doctrine of caloric with experience, it would be necessary to admit the creation of it—a substance—in the production of heat by friction. But, even against so absurd a proposition, he proceeded to prepare, when he subjected to a comparative investigation the *quantities* of energy expended and heat produced in such an operation.

In his "Experiment No. 3" he made, as may have been already noticed, nearly all the observations and corrections necessary for an entirely trustworthy estimate of the "mechanical equivalent of heat;"[1] and, although never literally employing such a term, he subsequently stated, in reviewing still other experiments undertaken at

[1] Its value from the *data given* may be calculated as follows:

Considering the shape of the borer, and its contact with the bottom of the cylinder, we see that the moment of friction may be represented by the expression—

$$4fp\int r^2 \sin^{-1}\frac{a}{r}\,dr,$$

where f denotes the coefficient of friction, p the total pressure between the rubbing surfaces, r the variable distance from the axis, of any rubbing particle, and a the half-width of the borer: when, moreover, the superior value of r alone is substituted.

The integral indicated is—

$$4fp\left\{\frac{r^3}{3}\sin^{-1}\frac{a}{r}+\frac{ar}{6}\sqrt{(r^2-a^2)}+\frac{a^3}{6}\log\frac{r+\sqrt{(a^2-a^2)}}{a}\right\},$$

about this period,[1] that the heat so generated "*is exactly proportional to the force with which the two surfaces are pressed together, and to the rapidity of the friction:*" in other words, that the production of heat is "exactly proportional" to the work expended in producing it.

First drawing attention to the absurdity of an apparatus containing or creating an indefinite supply of a material substance; then proving by experiment that the quantities of heat excited in a given time were proportional to the expenditures of an entirely different magnitude — work: he must be credited not only with the first conclusive, but with the most weighty argument initially available, against the existence of caloric, or in favor of the dynamic origin of heat.

OPEN AIR AND HEALTH.[2]

By Dr. PAUL NIEMEYER.

I SPARE the reader the diffuseness of an introduction, by telling him of a scene in an omnibus, which hinged on the question whether the conductor should open or shut the windows. On the left was

in which the substitution of Count Rumford's data,

$$p = 10{,}000 \text{ lbs.}, \qquad a = 0.3 \text{ inch}, \qquad r = 1.75 \text{ inches},$$

gives for the approximate moment of friction of the borer, in foot-pounds,

$$800\,f.$$

So that, making thirty-two revolutions per minute, a quantity of work, 160,800 f, would be expended during the same interval.

On the other hand, the heat excited in two hours and thirty minutes, and which, dynamically, was to be regarded the equivalent of the work expended, according to Count Rumford's estimate, was sufficient to raise the temperature of 26.58 pounds of water 180° Fahr., or 4,784 heat-units. The production of one heat-unit, therefore, corresponded to the expenditure approximately of an amount of work—

$$5041\,f,$$

For $f = 0.15$, this would give 756
" $f = 0.20$, " " " 1008

as the equivalents in mechanical units or foot-pounds of one British thermal unit.

Prof. Tait, availing himself of the remark let fall by Rumford, that "the machinery used in this experiment could easily be carried round by the force of one horse," and assuming 30,000 foot-pounds as the value of a horse-power per minute, thus derives 940 foot-pounds as the mechanical value of a rise of temperature of 1° Fahr. in one pound of water. (*See* "Historical Sketch," p. 9.) But Prof. Thurston regards this calculation as unfair to Rumford, quoting Rankine's estimate of the admissible value of a horse-power, 25,920, from which the value of the equivalent, 812, results. This critique also seems the more allowable, since Rumford neither made corrections for the work expended in friction in "the complicated machinery used" in the determination, nor for "the heat accumulated in the wooden box, nor for that dispersed during the experiment." —(*See Journal of the Franklin Institute*, 3, lxvii., p. 203.)

[1] "Kleine Schriften," 1805, vol. iv., p. 41. "Complete Works," Am. Ac. ed., vol. ii., p. 209.

[2] Translated from the German, by J. Fitzgerald, A. M.

seated a corpulent lady with full face, shrill voice, and labored respiration. The lady on the right was of lean, slender, dried-up figure; on entering the omnibus she had coughed; after taking her seat she held her handkerchief to her mouth and fairly changed color when the one opposite, wheezing, took her place and called out for "Air, air!" exclaiming that she would surely be smothered if the window were to remain closed. "But I," objected the other, "should get my death of cold if the window were opened." The conductor, who for some time stood undecided what to do, received this piece of Solomonic advice from one of the passengers: "Open the window," said he, in a deep voice, "and then one of them will die; then close it, and the other will die, and so at last we shall have peace."

This ending of the scene I state for completeness' sake only, and I add to it, by way of transition to the subject of the present essay, a conversation with a farmer which grew out of the occurrence.

On expressing to this sun-bronzed young man my regret that, in this self-styled "age of intelligence," the fear of colds and of draughts should be steadily increasing, and that it should really be producing the very effects it is meant to guard us against, namely, coughs and colds, he fully agreed with me, but took credit to himself for having risen above such notions. "We farmers," said he, "no longer believe that rust in grain comes from cold; for we know that it results from the development of noxious germs which, emitted by barberry-bushes and decaying stalks, are carried about by the wind."

This idea was of interest to me; for the farmer's account of the origin of "rust" put me in mind of certain throat and lung complaints that, developing unnoticed, gradually lead to positive disease, and the causes of which we physicians are daily more and more clearly tracing to inhalation of impure, vitiated air; hence, instead of speaking of consumptive lungs or tuberculous lungs, we should, rather, speak of "decayed" lungs or "dust" lungs. Stone-cutters are not assured by life-insurance companies, because it is known that the stone-dust settles in their lungs, undermining them, producing ulcerations and reducing the average life of the men to thirty-six years. Other "dusty occupations," so to speak, are less dangerous, but of certain callings and of certain classes of working-men we often hear it said that they are seldom free from "dry" cough. The reader, though he or she may have little to do with dust, will perhaps have taken home from the ball a very fair case of "dust-lung" caused by the dust of the dancing-floor. If they will not believe this, let them examine their expectoration the day after the ball. He who has good lungs may without fear inhale dust; he will dance most of it out again; but not so a delicate girl, whose lungs are compressed in a tight corset: when with dust-laden mucus she spits blood, do not say she has "taken cold." No, it is heating that has caused it.

Heating, too, and not cold, far less "trouble with teeth," is to

blame when the first-born child of inexperienced young married people becomes feverish, or has a cough, and these symptoms are only aggravated when the innocent victim is treated with "teas" and mixtures, kept in an overheated room, and loaded down with bedclothes.

That our children were intended by Nature to live in fresh, open air, and that the old wives' regimen of keeping warm, living in-doors, and of warm drinks, is the cause of the fearful mortality of young children, is a truth that was not unknown one hundred years ago, but which must still be repeated over and over again.

The reader will allow me to recite the case of a patient of mine. A year ago, during his honey-moon, I congratulated him, and told him that a dry cough with which he was troubled was curable, provided he took care to live in the open air as much as possible, inuring himself to cold, sleeping in well-ventilated chambers, free from dust, etc. But this advice was hardly relished by the young pair. In October they hired rooms in a house that had just been built; its "dampness" they remedied by keeping up fires steadily; the windows were hardly ever opened, as the house stood on a windy corner, and the husband was growing more and more sensitive to cold; for this reason, too, he seldom went out-of-doors. In November he took to the bed, was again about, but he gradually declined, to the last hoping to recover.

Different was the course followed by Mr. H——, who, emaciated and troubled with a cough, had a hæmorrhage after contracting a "severe cold." He went into the country, took as much exercise as he could in the open air, and returned home with only a slight cough. At home he every morning took a warm bath with affusions of cold water, avoided rooms with bad air, etc. In six months he was free from his cough, appeared to be well nourished, and no longer had any fear of taking cold.

If the reader will dispassionately compare these two cases, he will agree with me that the first patient, who had never had hæmorrhage, fell a victim to the action of foul air, while H—— used to say, "I must give to my diseased lungs, above all things, fresh air, as the prime necessary of life." Animals never take cold, even in winter; therefore among men it must be a result of wrong habits if air does any harm. We know that gold-fishes quickly perish when fresh water is not provided for them; and when we were boys we used to consider it cruelty to animals if we made no openings for ventilation in the boxes in which we kept cockchafers.

Now, these openings answer to the windows in our houses; doors are meant to be closed, windows to be opened. It has long been held that closed windows are the principal cause of consumption. I would make the proposition more general, by substituting "defective ventilation" for "closed windows." It is very pleasant to be sheltered by

four walls against wind, rain, and cold; but, now that we employ window-glass, coal for heating, and iron stoves, and rent is becoming higher, while rooms, especially sleeping-rooms, are growing smaller, we have all the greater reason to keep open ventilating apertures, since our lungs cannot live with less than six hundred cubic feet of fresh, pure air per hour. The man who has but once made trial for one week of sleeping with the window open will never give up the practice.

I once spoke to a lady about this matter, but she replied by telling me the story of a "thoughtless person" who, having left the window open through the night, awoke in the morning blind. She had also read in some newspaper that a man had a stroke of apoplexy produced by the same cause. I was amazed. But, calling to mind that this lady's husband had served in the army, I remarked: "Your husband lay for so long in the open air in the rain-drenched trenches at Strasburg; did he ever write to you that he had taken cold, or that any of the men had ever overnight been struck blind, or had met with any other misfortune? Did he ever contract a catarrh? Did he ever write for licorice, and not rather for tobacco? Your brother-in-law tramped in the deep snow to Besoul, your cousin learned at Le Mans what is the meaning of a fall of freezing rain, and thousands of our countrymen have had like experiences; still, coughs and rheumatism were not frequent, and most of the men came back strong and healthy!"

More rational opinions are gradually making their way, and, in one particular at least, a beginning is being made of a revolution, namely, the system of treatment followed in "climatic" sanitariums, and establishments for the cure of disease by air, difference of elevation, etc. The proprietors of such places, it is true, speak of the "specific" virtues of their climate; but, inasmuch as chemistry shows that atmospheric air all over the earth has the same constitution, the specific virtue must reside in the special purity of the air—a thing wanting in cities, but found in all villages, provided they do not possess large factories. Further, it is an error to suppose that in the south—Florida, Colorado, or in the Tyrol, or by the lake of Geneva—it is as warm as in a hot-house. In those regions, too, it is now and then cold; yet it is easier to be out-of-doors there, for usually the sun shines and the landscape is beautiful. But, since we cannot send all the sick to the south, we must devise some substitute at home, the benefits of which may be enjoyed even by the poorest. Then, too, when we consider that the majority of those who have spent the winter in a southern clime return as—embalmed corpses, because it is only when it is too late that people make up their minds to make the costly voyage, there is reason to expect better results from timely recourse at home to "air-cure." With the means of treatment at hand, disease might be nipped in the bud, and lung-complaints in general would be rarer.

And this result we may hope to attain. That pulmonary consumption is only an acquired disease we know from the fact that it first appears in the apices of the lungs—a portion of the organ which is not affected by hereditary pathological processes. The diathesis only is hereditary, and this diathesis consists simply of a general debility, which, however, can be overcome. But the thing that is transmitted hereditarily is habits of life—the avocation descending from father to son.

MacCormac tells of a family in which father, mother, and six children, died of consumption; the seventh son alone survived, he having quit the paternal house and calling, and gone to sea. Many instances of a like kind might be cited. This case is easily understood when we consider that here the parents and the six children who died had followed a sedentary trade; that they lived in narrow quarters, the air of which was quickly vitiated by the large number of persons breathing it; that they slept in a dusty room, with windows closed, lest they should take cold. They fell sick one after another; but the seventh son, who quit the unhealthy locality, had exercise, inhaled fresh, pure air, became vigorous and healthy, and escaped from consumption.

This simple explanation appears strange to those who believe in "tuberculosis." If this disease has grown to be the curse of modern society, the scholastic interpretation of it has to bear no small part of the blame. The doctrine of the heredity of consumption leads to the belief that the consumptive patient is fated to die of his complaint, and that his death is merely a question of time. He himself often draws the conclusion that the best thing for him to do is to enjoy life as best he may while it lasts. On the other hand, we must condemn the heedlessness of those who, so long as danger is not proximate, fear the expenditure of time and money. These same people, when hæmorrhage suddenly appears, quite lose their heads, adopt the most preposterous methods, whose only result is to cause new hæmorrhages, and to produce a regular case of consumption: whereas many of the old physicians recommend horseback exercise as the best cure for those suffering from hæmorrhage of the lungs, we now often see patients shut up in a hot, dusty room, not allowed to talk, and almost forbidden to breathe.

It is a peculiarity of consumption that it may appear in association with all diseases in which recovery is slow. In the first place, it accompanies inflammation of the lungs, unless the patient, while recovering, is permitted to breathe plenty of pure air. But it also makes its appearance in typhus, diabetes, and meningitis, when the patient is kept for a long time in a close room. So, too, delicate persons —those supposed to tend toward consumption—will all the sooner become indeed "tuberculosed," the more they are coddled, protected against cold, and treated with warm drinks and so-called "invigo-

rants." Pulmonary hæmorrhage is in itself not a symptom of "tuberculosis," but it is made so by wrong treatment.

The foregoing practical considerations will enable the reader better to appreciate the theoretical observations which follow.

The lungs, like all mucous surfaces, secrete mucus even in their healthy state; this collects while we remain quiet, but is thrown out when we move. Every adult person clears his throat in the morning. One who has been sitting for a long time must cough when he goes out-of-doors. Bodily movement is the best "solvent" for a cough. When one's life is sedentary, mucus collects first of all in the apices of the lungs, and it is more difficultly broken up there by bodily movement, because the apices are the uppermost parts of the lung, and the impetus of the cough must drive the expectorated mucus around the corners of the lung. The apices are a veritable receptacle for mucus, which, if not removed, dries up, grows hard, and causes ulceration. In one hundred autopsies we find as many as ninety cases where the apices are more or less shrunken, scarred, and obstructed, and this without reference to the cause of death.

The apices, furthermore, are regular dust and gas traps, especially the right apex, which usually is the first to be affected by consumption, because the air-passage leading to it is wider and less crooked than that leading to the left apex. All impurities inhaled into the lungs, and especially all dust, first make their way to the apices, and there settle, unless they are kept in motion by bodily exercise. Elimination, too, is more difficult in the apices than in the inferior lobes. In coughing, the latter are aided by the abdominal pressure; while the apices, on the contrary, have to depend on their own contractility, which is weaker in proportion as they have been out of exercise, or as their cell-walls have grown together. Heavy clothing, which, like the yoke for carrying water, bears on the collar-bone, diminishes the power of respiration in the apices; a modern winter-overcoat weighs as much as eight or nine pounds. If, in addition to this, we have the usual two turns of a comforter around the neck, then the neck is bound fast, and we have all the conditions necessary for producing a diseased condition of the apices. Under such circumstances it would require considerable exertion in coughing to clear the apices. Hence the troublesome dry cough, which often ends in vomiting, yet does not loosen the mucus in the lungs. No benefit is to be got in such cases from lozenges, drops, extracts; the most that can be expected from such remedies is that they may moisten the throat rendered dry by the effort of coughing. But then they fill the stomach with phlegm. For small children such substances are an actual poison, producing sour stomach, diarrhœa, and fever.

Continued hard coughing in time injures the texture of the lungs, and leads, often with bloody expectoration, to decay of the apices, and, finally, to true pulmonary consumption, concerning the rational treatment of which we add a few words:

As a general rule, where a cough is habitual, whatever the age of the patient, recourse should at once be had to those means of cure which usually are resorted to only at the last moment, and then without any hope of good results. But, unfortunately, most people think only of the present moment. They want a son to complete his schooling as early as possible, and to go to earning money. But what is the gain if the young life, after a few years, ends its earthly career? Better, therefore, that a year or two should pass without remunerative employment, while in the mean time care is taken of the bodily health and strength, the affected lungs are invigorated, and the spirits are renewed. In the first case we have dead capital, in the second capital which bears interest.

The person whose lungs are affected must once for all give up dancing, for dancing as now practised is not "motion," but only destruction of the pulmonary apices by dust and vapor, fatigue of the body through want of sleep and privation of fresh air.

With this one exception, "caution" as usually understood is bad. Let the one who is threatened with consumption look on himself not as one doomed to die, but only as a pulmonary invalid. He should consider that, while it is a misfortune that the pulmonary apices are from their position exposed to disease, we nevertheless have plenty of lung-cells which can be made to do duty in place of them. Still, if these are not daily strengthened by careful treatment, they are in danger of being infected by the others, and of becoming diseased like them. By timely and continuous exercise, it is possible to restore even the diseased cells, and to cure the consumption, or at least to stay its further progress. If one can find the means of visiting Florida, Colorado, or Southern Europe, it is well to do so. But if this is not possible, one must find the means of an air and movement cure at home. That this is possible, the reader will see from the following analysis of the means of cure:

1. Lung-Ventilation.—The patient must with scrupulous conscientiousness insist on breathing fresh, pure air, and must remember that the air of closed rooms is always more or less bad, impure. No man, however uncleanly, would drink muddy, dirty water. Unfortunately, for detecting impurities of air, the only organ we have is the nose, and in most persons the nose is of so obtuse a sensibility that it is of no service. Besides dust, injury to the lungs is caused principally by the products of respiration (carbonic acid and watery vapor), which act as poison on the lungs and the blood. A party which occupies a room for hours, breathing the same air, might be compared to a party of bathers drinking the water in which they bathe. The man who on the street cuts off from his lungs the "cold" air, is like a ruminant. If this literally true comparison were universally accepted and acted on, the number of cough-complaints would be reduced one-half.

The patient must keep the window of his bedroom open. Night-

air is fresh air without daylight; he who fears night-air is like a child who dreads darkness; the light in the room after the lamp is extinguished is also night-air. In close, crowded, heated rooms, the patient suffering from lung-complaint respires consumptively. In winter artificial heat may be employed, but the window must be opened above, and thus we have at once both warmth and ventilation. In the city night-air is always wholesomer than day-air, being both purer and stiller.

If it be objected that "what suits the blacksmith does not suit the tailor," I reply that may be true of a plate of sauerkraut. But here the case is just the reverse. The blacksmith who has no trouble with his lungs can stand vapor-dust, heat, fatigue; but the one who has pulmonary disease risks his life if he has not always abundance of fresh, pure air.

So far of the What?—lung ventilation. Next, of the Why?

On rising, let the patient drink fresh milk (not coffee), which will be relished all the more if one wakes with an inclination to cough. Then let him approach the open window, brandish the arms over the head—which enables the lung apices to inhale air more easily—and for a few minutes fetch as deep inspirations of air as possible. He must frequently take such deep inspirations in the open air.

If the lungs do not become free, let him introduce into them—not into the stomach—something to act on the dry mucous membrane—as the vapor of water or of camomile-tea.

If the cough is caused rather by a "scratchy" feeling in the throat, if it is spasmodic, let him swallow or gargle some substance that will quiet the nerves. Cold water is best—in summer ice-water; in some cases cooled fennel-tea is of service, but not sirup or any hot drink.

2. Skin-Ventilation.—This is of no less importance for warding off simple coughs, as well as for preventing the transition to consumption. With its millions of pores, the skin is on the one side the main sewer for carrying away superfluous fluids, and on the other it is the principal factor in cooling the body, in colds, in overheating, and in fevers. We will now consider skin-ventilation from this point of view under the two heads of—*a.* Elimination of fluids; *b.* Reduction of temperature:

a. Elimination of Fluids.—Like the external skin, the inner skin, the mucous membrane, exudes moisture, sweats. The mucous membranes, having no covering, are always moist. The mucous membrane of the lungs exhales watery vapor. This vapor comes from the serum of the blood, i. e., from that portion of the blood in which the corpuscles are suspended, and which, after the corpuscles have been filtered out, resembles water. The external skin under ordinary circumstances gives off about twice as much watery vapor. But, in proportion as this elimination is checked by defective skin-ventilation, the water

of the blood (serum) has to be eliminated internally through the mucous membranes. Cooling, i. e., the sudden action of comparatively low temperature on the warm surface of the skin—for instance, when one sits in a draught of air—may check transpiration, and so cause the fluids to tend inward in such volume as to overtax the capacity of the mucous membrane of the lungs or the intestines, more rarely of the kidneys, the result being catarrh. But catarrh and coughing are two different things: as for "dry cough," it can never arise from cold. That it results from the inhalation of impure, vitiated air, the reader knows already. It is true that obstruction of the breathing-apparatus, as "rattling" in infants, and hawking and hoarseness in grown persons, results from retention of serum; but that this obstruction is not connected with taking cold must be admitted, at least in all cases where the patient has not quit his chamber, or even his bed. As a matter of fact, no one takes a cough from a cold wall or from an open door. The conclusion to be drawn from all this is, that the coughs, hoarseness, and sore-throats, from which those persons suffer in winter who are ever on their guard against colds, are produced, not at all from cold, but from its contrary, overheating of the skin, whose evaporation is feebler the nearer the external temperature approaches that of the body. In this case there is a suppression of the action of the skin, but it is produced not by cold but by improper warming—or, as it is more properly called, by pampering. A hot bath, a cold pack, or a good, lively walk, will work wonders in "loosening" a hard cough. At first, it is true, the patient will cough harder than ever; but this effect is not due to the "cold wind," but to the fact that the accumulated mucus, once started, is expelled *en masse*. The oftener the patient resorts to the bath, to the pack, and to walking, the less frequent are the fits of coughing, and the freer and easier does he breathe.

b. Reduction of Temperature.—The body's temperature is normal when in the armpit it is about 95° Fahr. Food and drink are stimulants, and the skin is the radiating surface which gives off the surplus heat. If this elimination is not sufficiently active, the body becomes overheated, and this manifests itself by shivering. Overheating is the result when one eats and drinks much, at the same time parting with but little heat. The chill so produced is usually called "inward cold," but this is an error: it is overheating. That this is so is shown from the fact that when on the morning after a "social evening," during which we were overheated, we feel chilly, we have only to take a walk until perspiration is set up; we then feel warm again in spite of a considerable cooling off. And this, by-the-way, is the very best cure for the "Katzenjammer." We live in a climate where it is far easier to heat the body than to cool it. Hence one of my counsels against catching cold is, that the weakly, coughing reader of sedentary habits should not overheat himself with strengthening food, so

called (meat, eggs, beer), else he might take an "inward cold," or even a fever.

But a person may contract a genuine (external) cold by unwise precaution against draughts — by neglecting the skin-ventilation. Under this head of unwise precaution we must class the habit of wrapping up the body when it is in a state of perspiration. On the contrary, coat and waistcoat must then be opened so that the shirt may dry quickly, and the underclothing, including the stockings, must be changed. But what does he do who on reaching the top of a mountain, with a wet shirt, buttons up his coat about him, puts on his overcoat, and over all his plaid? He applies a wet poultice at the wrong time.

Prof. Tyndall, in his "Glaciers of the Alps," tells us that, on being overheated during his rambles in the Alps, he at once took a bath, or poured water over his body. "*Probatum est*," say I, from personal experience.

"Yes," some one will say, "you are inured to that sort of thing." To be sure I am! But what hinders you from being inured also? Just go out on the ice during this glorious winter weather, put on a pair of skates: you will return bright and fresh; you will throw open the windows, and be indignant at yourself for ever having shut yourself up in such a steaming atmosphere. The next day take a simple bath—not a Russian or a Turkish bath at all—and you will rid yourself of still another part of your phlegm.

3. Muscle-Ventilation.—Muscular fibre respires too, i. e., gives off carbonic acid and takes up oxygen. To this end it must diligently contract and then relax; in short, it must work, or, if the reader prefers the expression, it must practise gymnastics. Whether one takes his exercise at home or abroad, makes no difference. They whose lungs are affected would do well to climb hill-sides, for in such exercise the apices of the lungs are most called into play; in climbing the hands may rest on the hips. Muscle-exercise is not to be separated from lung-exercise. If bodily movement be neglected, deleterious fluids accumulate, which I call "suffocation-blood" and "fatigue-blood." The former contains carbonic acid, which makes one always drowsy, and causes one to go about his day's work with a feeling of lassitude no matter how long he has slept. This feeling of weariness grows steadily worse. "Fatigue-blood" accumulates in the muscles as a result of drinking wine and beer; even simply bending the body causes inconvenience; one feels quite unstrung and wants to recline on a lounge or a bed, whereas what he ought to do is to take a brisk run in the open air, or a little exercise in a gymnasium. In this way the skin is ventilated and the serum worked off.

My essay cannot exhaust all the topics named in its title: the most it can do is to awaken attention, free the reader from certain erroneous ideas, and lead him to believe that the simplest remedy is always

the most natural and the best. If any one will put his faith in recipes, I would remind him of the history of the sale of indulgences. We look back with indignation to Tetzel's scandalous work, but how many people still think they can purchase health by gorging themselves with medicines! Consumptives form no small portion of this class. The treatment here recommended costs no money, but demands only will, self-conquest, and perseverance. The treatment is not so complicated as it may appear; it is simply a movement and an air cure, or, more briefly, an "attempering" cure, for effeminacy is the source of all colds, coughs, and consumption, and hardening is the only protection and remedy against them.—*Der gemeinnützige Gesundheits-Almanach.*

THE TIDES.

By Professor ELIAS SCHNEIDER.

II.

A PART of the theory of the tides presented in our text-books has been pronounced absurd in my first article. It is also a matter of amazement that the effect of centrifugal force is entirely ignored in these text-books. That the propelling force arising from this cause should be utterly disregarded in an explanation of the tides is very remarkable. And yet the existence of such a force is so easily demonstrated that nothing else seems necessary to prove it to be one of the causes of the tides, than what was presented in my first article. I will, however, give additional force to my reasoning by citing the results of actual experiment.

It may be shown that there is an actual difference in the amount of centrifugal force felt at any part of the earth's surface during different times of the twenty-four hours of one axial rotation; and also at different times of the earth's revolution around her centre of motion. Theory implies that when any portion of the earth's surface is moving toward that point in her orbit where such surface makes the most rapid sweep around the centre of motion, the greatest amount of centrifugal force must be felt at such surface; and that, when this part moves toward that point of the earth's orbit where it makes the slowest sweep around the centre of motion, the least amount of centrifugal force must be felt. Now, it is very evident that any portion of the earth's surface which is most remote from the centre of her motion, whether that centre be the sun or the centre of gravity between herself and the moon, makes the most rapid sweep, and that consequently her waters must feel the greatest amount of centrifugal force at that time.

Now, let us see what experiment tells us on this subject: A box has been made of proper dimensions, free within from all outside disturbance or motion of air. In this box is placed a steel frame, which moves like a gate on a very delicate hinge, so as to avoid all possible friction. A weight of nearly twenty pounds rests on this gate at about four feet from the hinge. The hinge, whose lower part is a mere point, or delicate pivot, and the weight, are in the same line, parallel with the meridian. The weight is free, as nearly as can be, to obey the power of its own inertia. In consequence of this it moves laterally once every twenty-four hours west and east, whenever the centrifugal force is increasing and decreasing.

From noon to midnight the earth's surface is moving toward that point where its motion is more rapid, and consequently it begins to feel an increasing amount of centrifugal force. This is indicated by the apparatus, for the weight, which rests on the gate, by virtue of its inertia, lags behind and makes an apparent motion westward. This motion is, of course, not real. The earth's surface moves eastward faster than the weight, and hence the weight appears to move westward. From midnight to noon the centrifugal force felt by the earth's surface diminishes, for it is then moving toward that point where its motion eastward is less rapid. This is also indicated by the apparatus, for the weight, having gradually acquired the same velocity eastward, remains stationary at midnight a very short time. But, soon after midnight, when the earth's surface begins to feel less centrifugal force, this weight, by virtue of its inertia, resists the change of motion, and therefore moves eastward as far as it moved westward before midnight.

This movement of the weight is greatest when new-moon occurs at midnight, for the earth then feels not only the centrifugal force produced by her revolution around the sun, but, in addition, that produced also by her revolution around the centre of gravity between herself and the moon.

The motion of the weight westward begins soon after mid-day, and reaches its highest acceleration at about 8 P. M.; the motion eastward begins soon after midnight, and reaches its highest acceleration at about 7 A. M.

I hope soon to make a new apparatus, which shall have a longer distance between the hinge and weight, and from it more marked results can be derived.

When a body moves in a curve around a centre, it feels the effect of two forces: the one, which I call centrifugal, is the impulse which puts the body in motion; the other, which I call centripetal, is the power which draws toward the centre and keeps the body from moving in a direct line. These are the only forces acting upon a body moving in a curve. The former is sometimes called tangential, but I prefer to call it centrifugal, for it is the only force which drives from

the centre. There *is* no force acting directly *from* the centre. That which is often called centrifugal is really centripetal force, for the tension of the string in the following experiment is not caused by any force acting on the body *from* the centre, but it is caused by a force drawing the body out of its rectilineal course, and *toward* the centre, compelling it to move in a curve.

Suppose the body *E* (Fig. 1) moves with a certain velocity in the curve *E C D*, and that the string *E S* feels a known tension, just equal to its strength. Now, double the velocity, and the strength of the string must be increased fourfold to keep it from breaking, for the force drawing the body toward the centre must then be four times as great to keep it moving in the curve. Or, suppose the body moves from *A* toward *B* with a known velocity, and that on reaching *E* it is acted upon by the string. The body is then made to take a curvilinear motion, and the string feels a tension drawing the body not directly from but toward the centre, and equal to a force necessary to keep the body from moving in a straight line. It may be remarked that, as action and reaction are equal, the tension is felt both ways. But the reader can easily see what I mean.

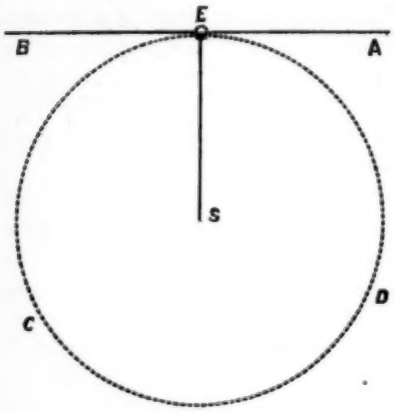


FIG. 1.

This law of motion can be still better illustrated by a reference to one of the satellites of the planet Neptune. The mean distance of this satellite is nearly equal to the distance of our moon from the earth. We may assume these distances to be exactly equal. Then, as at the same distance the centripetal force must increase as the square of the velocity, to keep the body moving in the curve, and as the velocity of this moon of Neptune is about four and a half times greater than that of our moon, the centripetal force, or the force of gravity produced by Neptune on this moon, must be $(4.5)^2$ about twenty times as great as is the centripetal force or the gravitating power our earth produces on its moon. In other words, the planet Neptune is about twenty times as heavy as our earth, for weight is nothing else than the measure of gravity.

The preceding statements are sufficient to show what is meant by centrifugal and centripetal forces. Let us now see how these act on bodies moving in large and small curves, and how the waters on the earth's surface are driven by centrifugal force toward a line tangent to her orbit. Since the length of the orbital curve of the earth is

very great, and therefore not much deflected from a straight line, the waters are driven very little above the usual surface, no matter how rapidly the earth herself may move in this curve. The centrifugal force or original impulse felt by the whole earth is very great, but that felt by her waters is hardly visible or sensible in mid-ocean. For the tide-waves cannot get above the line tangent to the curve of the earth's orbit. The following illustration will show this:

Let *A B C* (Fig. 2) represent a part of the curve of the earth's orbit, in its motion around the central sun, and *B D* a line tangent

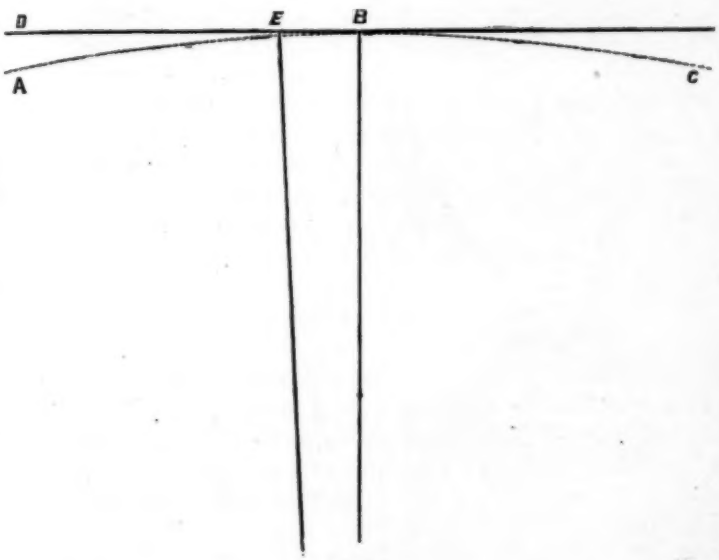


FIG. 2.

to the curve at the point *B*. Now it is very evident that no tide-wave produced by centrifugal force can get higher above the curve of the orbit than this tangent line, and the distance between the curve and the tangent, as at *E*, is very small. The part of the earth's surface most remote from the sun has indeed a greater tendency to continue moving on in the straight line of the original impulse than any other part. The particles of water have a small degree of cohesion, and they will therefore continue to move a short distance along this tangent, but only a little above the usual surface of the earth.

The curve in which the surface of the earth moves around the centre of gravity between herself and the moon is much more deflected from a straight line. Here also the tide-wave can rise no higher than to the line tangent to this curve. The distance of the point *G* (Fig. 3) from the curve is, however, much greater than the point *E* in Fig. 2 from its curve. The motion of the surface of the earth at *H* around

the point *C*, the centre of gravity between herself and the moon, is only about sixty-five miles an hour; while the surface at *B* (Fig. 2) moves with a velocity of 68,000 miles an hour around the sun. Nevertheless, as the waters are driven toward these respective tangents by the effect of centrifugal force, the tide-wave must be greatest where the distance between tangent and curve is the greater.

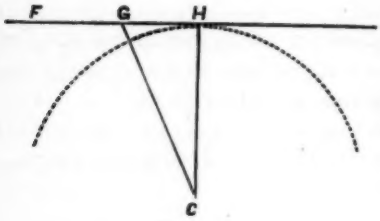


FIG. 3.

Let us now proceed to prove by mathematical demonstration the falsity of the theory of the tides found in our text-books.

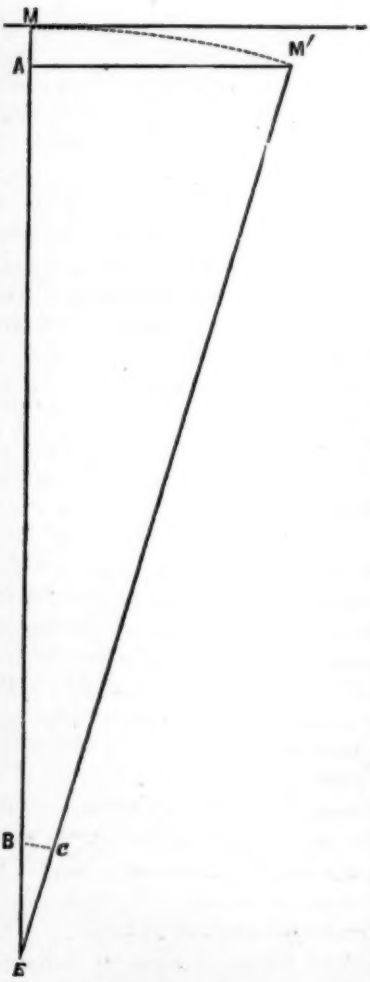


FIG. 4.

Herschel, in his "Outlines of Astronomy," uses the following language: "That the sun, or moon, should by its attractions heap up the waters of the ocean under it seems to them (objectors) very natural. That it should at the same time heap them up on the opposite side seems, on the contrary, palpably absurd. The error of this class of objectors . . . . consists in disregarding the attraction of the disturbing body on the mass of the earth, and looking on it as wholly effective on the superficial water. Were the earth, indeed, absolutely fixed, held in its place by an external force, and the water left free to move, no doubt the effect of the disturbing power would be to produce a single accumulation vertically under the disturbing body. But it is not by its whole attration, but by the difference of its attractions on the superficial water at both sides, and on the central mass, that the waters are raised; just as in the theory of the moon the difference of the sun's attractions on the moon and on the earth (regarded as

movable, and as obeying that amount of attraction which is due to its situation) gives rise to a *relative* tendency in the moon to recede from the earth in conjunction and opposition, and to approach it in quadratures."

This language gives about the clearest presentation we have of the pulling-away doctrine. But there *is* no "tendency in the moon to recede from the earth in conjunction and opposition, and to approach it in quadratures." On the contrary, the tendency of the moon's motion is just the reverse—namely, to approach in conjunction and opposition, and to recede in quadratures. And if so in regard to the moon and earth, it must be still more so in regard to the earth and her waters under this influence alone, as can be demonstrated.

I am sustained in my position by the best of authority. "Thus our moon moves faster, and, by a radius drawn to the earth, describes an area greater for the time, and has its orbit less curved, and therefore approaches nearer to the earth in the syzygies than in the quadratures. . . . The moon's distance from the earth in the syzygies is to its distance in the quadratures, in round numbers, as 69 to 70." The authority I quote is Newton's "Principia."

Let us make a calculation, and apply it to the earth and her waters. The moon performs its revolution in $27^d\ 7^h\ 43\frac{1}{3}^m$, which is equal to $2{,}360{,}606\frac{2}{3}$ seconds. The seconds of time in which the moon makes one revolution around the earth is to one second of time as 1,296,000 seconds in a whole circle is to a fractional part of one second of a circle, which we will call x. Hence $x = \frac{1}{2360606\frac{2}{3}} = .54901141+$, which is the fractional part of one second of the circle of the heavens the moon describes in one second of time. The semicircumference of a circle whose radius is one equals 3.141592653589+. Hence one second of this semicircumference equals $\frac{3.141592653589}{648000} = .0000048481368110+$, and the fractional part .54901141 + of one second of this semicircumference is equal to .00000266168242648 +.

Let $E\,M$ and $E\,M'$ represent the moon's distance from the earth, $M\,M'$ the arc which the moon describes in one second of time, and $A\,M'$ the sine of this arc. Let $E\,M'$ equal 240,000 miles, the moon's distance, in round numbers, from the earth, and $E\,C$ equal one mile. The arc $B\,C$, being very small, may be regarded as equal to its sine. The length of this arc we have already found. From similarity of triangles we have the following proportion: $A\,M' : B\,C :: E\,M' : E\,C$, or, by substituting the figures, $A\,M'$: .00000266168242-648 :: 240000 : 1. Therefore $A\,M' = .6388037823552+$, which is the sine of the arc passed over by the moon in one second of time. The cosine $E\,A$ is equal to

$$\sqrt{\overline{E\,M'}^2 - \overline{A\,M'}^2} = \sqrt{(240000)^2 - (.6388037823552)^2} + =$$

239999.9999991498535+, which, subtracted $E\,M$, gives $A\,M = .00000-08501464+$, and this fractional part of a mile, reduced to inches, gives

.053865275+, the fractional part of an inch as the distance the moon falls from a tangent to its orbit in one second of time. Multiply this by the square of 60, and we get, when reduced, 16.159+ feet, the distance the moon descends in one minute, which is equal to 15.1+ Paris feet, the result obtained by Newton in his "Principia."

The distance the earth falls, in one second of time, toward the sun is about .12144+ of an inch, and the distance the moon falls toward the sun in one second, when in opposition, is about .12084 of an inch. This, added to the distance the moon falls toward the earth in one second, makes .17470+. Now, .17470 − .12144 = .05326. Hence the moon, when in opposition, moving faster toward the earth than the earth does toward the sun, by .05326 fractional part of an inch in a second, these two bodies have a tendency to get nearer to each other in this position. The same can be proved when the moon is in conjunction.

Now let us see how this same law affects the waters of the ocean. The earth moves toward the sun .12144 part of an inch in a second. The waters of the earth, on the side turned away from the sun, are only 4,000 miles farther from the sun than the centre of the earth. Gravity toward any body diminishes as the square of the distance increases. Hence these waters, influenced by the gravitating power of the sun alone, and not hindered by any intervening object, would fall toward the sun .12143 part of an inch in one second. Hence the earth has a tendency to move away from the waters with a velocity of .00001 part of an inch in one second—that is, if these waters were not influenced by the gravitating power of the earth, and only by that of the sun, the earth would be "pulled away" from its waters at the rate of only the 100,000th part of an inch in one second. But it must be remembered that the waters gravitate, in addition to this, toward the earth at the rate of 16.15+ feet in one second, and therefore these waters are *depressed* by gravity, and not elevated. The same may be proved in regard to lunar tides.

I close by saying that I am an earnest seeker of truth, and nothing but a sincere desire for truth has impelled me to write these two articles. Any person attempting to prove me in error, with the same good motive, will be kindly welcomed.

MODERN SUPERSTITIONS.

MOST people accept it as a fact that superstition went out with the advent of steam, the telegraph, and the penny-post. A little honest observation, however, will assure us that there still exist a number of pitiable though petty superstitions. Among certain classes there are lucky and unlucky days in their calendar. They

will not attempt an important task on Friday. The horseshoe still hangs behind or over the door in the Highlands, and in some places much less removed from the centres of civilization. East-coast fishermen will yet occasionally burn, or otherwise destroy, a boat from which the lives of any of the crew have been lost, no matter how seaworthy or valuable the boat may be. A hare crossing the path of one of these hardy sons of the sea will cause him to forego an intended journey or voyage. To rustic and fisherman alike a concourse of magpies is an evil omen. As for dreams, the belief that they are the forecasts of events is perhaps the strongest of all the forms of their superstition. We might multiply examples, but have said enough to suggest that the follies of their great-grandfathers have still no slight fascination for the ignorant, in spite of the strides which intelligence has made.

But have superstitious beliefs quite left the more intelligent ranks of society? On the very subject of dreams itself is there not a sneaking credulity which goes far to prove the contrary? True, any one of us is quite able to account in a natural way for his or her dreams. Nevertheless, the lady who chides her children for repeating the interpretation which the housemaid has put upon their sleeping vagaries, and sagely instructs them on the subject of imperfect digestion and its effects upon the brain during sleep, is not ashamed to impart to her husband any morning the particulars of her own shocking dreams, or to piously express the hope that something untoward is not about to happen. Her better-half pooh-poohs the matter, doubtless, as becomes his superior dignity, but is visited none the less with a vague sense of uneasiness when he remembers that he himself had a vision of losing a tooth or seeing a house on fire. Having courageously quizzed his wife at the breakfast-table on the folly of *her* augury, and bidden her and the children good-by for the day, he inwardly deplores the unlucky omen of having to turn back for his forgotten umbrella or pocket-book!

How many curious but innocent little customs too are still current, and with the sanction of the wisest! An old slipper is still cast after a bride: it is considered necessary to christen a new ship with a bottle of wine: a fine day is still royal weather: and so on. These and many others most of us would indeed be sorry to see extinct. They are not only harmless, but, in their very departure from strait-laced common-sense, give an agreeable and perhaps even healthful relief to the prosiness of ordinary life. To sacrifice them to the strict letter of reason, would be to sacrifice much of the sentiment of life, to banish imagery from poetry, to take the perfume from the rose, to guide into a Dutch canal the current of human affections, which left free will gush and eddy, prattle and murmur by rock and meadow, carrying music and health throughout its living course.

Would that modern superstitions never took less innocent shapes!

Having discarded the ghostology of olden times, many people, and among these some men and women of considerable culture, have set up for themselves a novel system of intercourse with the unknown world. Brownies and fairies, with all the fine romance that surrounds the history of their doings among human folks, are dismissed with contempt. Spiritualism has swept all these ethereal puppets off the boards of ordinary life. To substitute what? We might at least look for an improved exhibition and more interesting "characters;" but the truth is, that nothing could be less satisfactory than the modern attempt at demon-craft. There is something so clumsy and inartistic in the whole get-up of the "spiritual" drama, that it is less surprising to find it very generally scouted than to see it obtain even a partial notoriety.

Ignorance is the parent of superstition, without a doubt; and the one never exists apart from the other. There is, however, a second wise saw that tells a great deal of the truth about the origin of that world-old bugbear of the human mind, namely, "The wish is father to the thought." What we strongly desire to be, we are next door to believing to be. The appetite of man's vanity is unappeasable, and in catering for it his fancy plays tricks with his reason. He longs for intercommunion with the unknown, and indulges the wish by creating fictitious agents for that purpose. Tokens, signs, omens, and auguries, are also outgrowths of the various forms of desire and vanity. We believe we shall have luck if we turn the money in our pocket when looking at new moon. Men have *waited* in all ages for the appearance of some favorable sign before beginning any enterprise of importance. If the sun shines on our wedding-day, how auspicious! Palpably in each case because we desire these things to be! But having set up omens with such an object, we, in the cleft-stick of our own superstition, are bound to believe their absence, or converse, the foreshadowers of evil.

In many ways modern credulity frees itself from such mechanical trammels as those we have mentioned, to take a form and complexion from the age, losing meanwhile not one jot of its vigor. To dream three times of a hidden treasure and set about, Whang-the-Miller-like, to lay bare the foundations of one's house, is an exploit not to be thought of by the veriest wiseacre of our day; but the desire to obtain wealth easily and rapidly being, if anything, more active and rampant, the belief in some magical means for attaining it is the most natural thing in the world. An El Dorado is required, and lo! an El Dorado is implicitly thought to exist. The projectors of a bogus company for "utilizing the clippings of old moons," or "extracting starch from granite chips," are the good fairies whom by propitiating with a portion of our substance we hope to enlist in our behalf, and obtain a thousand-fold return. Where such a superstition exists, and it is broadcast, any scheme, however absurd, any swindle, no matter how

transparent, will serve for a bait to catch the unwary and over-eager fish. Nothing is so purblind as undue acquisitiveness. The ancient Highlander with his keen eye to the main chance and happy facility for "attaching" whatever came in his way, found a beautiful horse in rich trappings, browsing ownerless in his path, and, following the instinct of his desire rather than the prudence which tradition should have taught him, rashly mounted. In an instant he was borne aloft, then plunged forever beneath the dark waters of a tarn on the back of the wily and terrible water-kelpie. We, too, have our illusory steeds in this so vaunted age, and neither the teachings of history nor the bitterest experience seems able to prevent the speculator from vaulting into the saddle, and forthwith launching into perdition.

Charms are things of the past, or believed in merely by the vulgar; that is to say, those pretty and fanciful conceits which led our ancestors to attach a healing or sanitary virtue to certain objects and ceremonies are now almost extinct. A spray from the rowan-tree is no longer a safeguard against an epidemic, nor the hand of majesty a cure for scrofula. Ladies do not now believe that the presence of a piece of cold iron on their couch, "*while uneasy in their circumstances*," will secure a happy consummation; nor is a child's caul in much request in these days as a protection against fire and drowning. True, we have got over these beliefs pretty thoroughly. But is the desire for infallible remedies and potent protectives done away with also? Not in the least; and though science is doing its best to provide honest substitutes in a natural measure, the public is not satisfied with its efforts. Quacks are the modern magicians, and quack medicines the charms of latter days. Those who are bald, for instance, will not accept their fate while a single well-puffed elixir with a Greek name remains untried. There is something saddening, if not sickening, in the evident success which attends the pretenses to cure chronic and irremediable diseases, to effect miracles in short with the most trumpery of means and execrably silly devices. Our forefathers were imposed upon, no doubt, but there was method in their madness. The "simples" with which spae-wives and charlatans professed to cure ailments were in many cases effective and now recognized drugs, and were at the worst perfectly harmless; while the rites with which they were administered, if quite apart from the purpose, yet appealed gracefully to the imagination. Nowadays, however, the "simples" are the patients and not the medicines! The old story. Childlike, the age cries for something that it cannot get, rejecting the good that is within reach.

In a recent number of this *Journal*, we had occasion to refer to the amazing credulity of Americans on the subject of professional "mediums." The worst of it is, that the extent to which this has been laid bare is insignificant compared with that which really remains unexposed. The desire to work with supernatural tools in effecting the

paltriest and meanest of human ends, would seem to have divided a people of accredited shrewdness into the two classes of rogues and dupes. But, as we have seen, we, too, have been singed at the same fire. There are, moreover, other if minor superstitions in our midst that suggest the propriety of beginning the task of reformation at home. An occasional glance, for instance, at the stock advertisements of leading journals, will convince any one how wide-spread is the infatuation that believes in spurious offers of advantageous employment. Some of these have, under our own observation, been repeated with little variation for more than twenty years; and we have no doubt that the wily advertisers are able to calculate to a fraction the number and gullibility of their dupes. We have from time to time drawn attention to swindles of this class, as well as to those tempting offers of "Money to lend," which appear with equal regularity in newspaper columns. We are afraid, however, that friendly warning and experience are alike unavailing to stem the mischief. The spread of education itself would appear unable to outstrip the spread of imposture or the eager credulity that supports it; for superstition merely shifts its ground from time to time, without losing appreciably its original dominion over the human mind.—*Chambers's Journal.*

SKETCH OF PROFESSOR RANKINE.

PROF. W. J. MACQUORN RANKINE was born in Edinburgh, July 5, 1820, and on Christmas-eve, in 1872, he died, before he had completed his fifty-third year; but in that comparatively short life he had won higher distinction and done more good work than it falls to the lot of most men to compass.

He pursued his ordinary school studies in the Burgh Academy of the town of Ayr, the high-school of Glasgow. When very young he entered the University of Edinburgh, where he devoted himself to natural philosophy and natural history, including zoölogy, geology, mineralogy, and botany. He was a born mathematician, and received little aid from professional instruction in the branch of science in which he subsequently displayed such great genius. Throughout his educational course he received valuable aid from his father, who was a retired lieutenant of the British Army.

His powers were developed at an early age. Before he was twenty he had written two essays on subjects in pure physics. At eighteen he adopted the profession of civil engineering, and was the pupil of Sir John Macneil for three or four years, a great part of which was spent on engineering works in Ireland. Subsequently, he was employed for several years on railways and similar works in

Scotland; and in 1850, forming a partnership with Mr. John Thomson, C. E., he settled in Glasgow.

Meanwhile he had been busy in purely scientific pursuits not connected with his calling, and the value of his work was generally recognized. He was elected to various learned societies, and in 1853 was made a fellow of the Royal Society of London. The same year he became a member of the British Association, in which he subsequently held several important positions. During the Dublin meeting of the Association in 1857, the honorary degree of LL. D. was conferred upon him by the university of that city as a mark of the eminence he had gained as a physical investigator. He was then but thirty-seven years old.

In 1855 he was made Regius Professor of Civil Engineering and Mechanics in the University of Glasgow, a position which he held with distinction for seventeen years. He was an able instructor, his aim being to develop the understanding of the student by the cultivation of natural knowledge, and to beget those habits of close observation and persistent and exact verification which are so essential to the scientific worker in any field.

Prof. Rankine was the first President of the Institution of Engineers of Scotland, and in 1861 was made President of the Philosophical Society of Glasgow, contributing many papers to the Proceedings of that Society, and on a wide range of topics. The honors he won in his profession, and in thermo-dynamics, were rivaled by his achievements in naval architecture, to which his attention was for some time given.

His writings were exceedingly voluminous. His published treatises and manuals included, among others, "Manual of Applied Mechanics," "Manual of the Steam-Engine and Other Prime Movers," "Civil Engineering," "Useful Rules and Tables," "Cyclopædia of Machine and Hand Tools," "Manual of Machinery and Mill-Work," besides a very long catalogue of papers on physics, especially thermodynamics, applied mechanics, etc. His style was a model of scientific writing—elegant, exact, lucid in explanation and apt in illustration. In short, his was a mind of the first order, his original investigations were of the highest value, and his excellent influence as an instructor in moulding the minds of his students will be far-reaching.

His early death was the penalty of overwork, and was preceded by an impairment of vision and a derangement of the heart's action that were very distressing. He yielded to the demand for bodily rest when it became imperative; but it was too late. His is another name added to the long list of those who, understanding perfectly the limits of human endurance, seem to think that their case is exceptional, that their organisms can be continuously overworked with impunity, and so go on, heedless of the dumb protests of the abused body, until the ruin is utter and irrevocable.

EDITOR'S TABLE.

LANGUAGE IN EDUCATION.

THE agitation for a reform in the Civil Service, as it is called, should it result in the establishment of that measure, may be expected to produce effects not now much anticipated or cared for. The essence of the reform is to consist in getting better men for office-holders than American politics has hitherto afforded—certainly a most laudable thing. But the mode of arriving at the better qualified men is to be by "examinations," that is, by the educational test. Before candidates can be examined, however, and decided upon, it will be necessary to arrange the standards by which they shall be judged, and one of the important effects of the system will be to bring to inexorable judgment those preliminary standards on which the whole policy must rest. One of the reasons why the superstitions and absurdities of education are so tenaciously persistent, is the difficulty of bringing the results of so-called culture to direct practical test or verification; but the examiners who frame the catechism by which candidates for office are to be sifted and accepted or rejected, cannot fail to do something toward the removal of this difficulty. In deciding what qualifications are desired, they will give judgment upon the method that has produced them.

The English have tried Civil Service reform sufficiently long to begin to connect cause and effect, and take account of the validity and worth of its standards. They began the system of Civil Service examination in 1853 by drawing up scales of the valuation of different kinds of knowledge as expressed numerically by marks, so that proficiency in the various branches could be added up and indicate the "standing," as is done in many schools. This scheme, of course, represented current ideas, and the Indian Civil Service Board decided that "in the two great ancient languages there ought to be an examination not less severe than those examinations by which the highest classical distinctions are awarded at Oxford and Cambridge." This was for those who aspired to civil positions in India; and how the knowledges were rated comparatively may be inferred from the following examples:

Greek	750
Latin	750
French	375
German	375
Natural sciences	500

This marked predominance of dead over living languages, and the still more striking predominance of language over science, could not fail ultimately to bring the whole question under critical scrutiny, and has led to a reëstimate of the educational value of lingual studies. We publish part of a paper read by Prof. Bain before the British Social Science Association, which deals with this important subject, and our readers will find it valuable as a contribution to education, regardless of the Civil Service interest, while it illustrates what must be the effect of that reform in bringing educational questions into a new aspect. The overshadowing predominance of language forces an inquiry which proves that it is of the very lowest possible use as a means of mental culture.

SAVINGS-BANKS AND STATE CONTROL.

THE recent scandalous revelations concerning the management of savings-banks and similar institutions of trust have, of course, provoked much dis-

cussion, and, equally of course, much loose talk.

The obvious fact that many of the men who have been chosen, or have assumed, to take care of the savings of the frugal have proved to be wholly unworthy shows, it is often argued, an alarming decadence in the moral tone of the community, which is variously ascribed according to political or religious bias. There are not wanting those who assert that the whole social organism is unprecedentedly corrupt, and that the facts which have transpired are but a faint precursor of what is to come. But it is by no means clear that any such doleful view of the situation is warranted. The morals of trade may be loose enough, but it is not readily to be admitted that they are deteriorating.

It is true that the early history of savings-banks in this country shows no such dark picture. Previous to 1862, failures were rare; the banks were, as a rule, safely managed by fit men. A high order of financial or executive ability is not required for the management of a savings-bank, but integrity and common-sense are; the right paths are straight and well beaten—what is needed is a steadiness of purpose to resist the temptations that lead away from them. During the last fifteen years the number of these institutions has largely increased, and the process of natural selection does not seem to have developed safe officials as fast as they were wanted.

Nor is it alone that it has been necessary to put many new and untried men in places of trust. A higher degree of rectitude has been needed to bear the strain imposed by the speculation and recklessness of a period of inflation than was sufficient in the less trying days which preceded this era—this has not always been found. The prudence of any given man or class is not a fixed quantity, it is subject to fluctuations; it is weakened by the spirit of confidence and rashness that always marks a period of rising prices, and strengthened by the heroic treatment of adversity which is sure to come in with the reaction.

Of the details of the mismanagement which has led to disaster, and of the rules for properly conducting such institutions, it is not our present purpose to speak; but there is one idea which seems to be fundamental in all the remedies proposed that deserves attention.

State control in some form is the sole corrective which, in the opinion of those whose views find expression, is available; and there is something sublime in the faith apparently felt in government management, even by those who are loudest in their denunciations of office-holders — the only agents through whom a state can do its work.

The recommendations all assume one of two forms:

1. That a system of post-office savings-banks, similar to those now operating in England, be established; or—

2. That more thorough state inspection be instituted with a view to maintaining and purifying the present system.

Opinion is still divided in England as to the ultimate success of the scheme for post-office banks, but it has, so far, worked too well to permit unqualified condemnation. This success, however, has been wrought under conditions that do not obtain in the United States.

In the first place is the wide difference in the Civil Service of the two countries. Without going into comparisons it is safe to say that, until our much-talked-of reform shall have made some progress, it may be as well to go slow in committing savings-deposits to the custody of an irresponsible, ever-shifting set of officials, chosen without any reference to their natural fitness or training for the discharge of such a trust. We already hear much of their delinquencies, and it is certain that the pro-

posed system would add to their temptations and the risk of defalcation.

Secondly, the difficulties in working the system are greatly enhanced in this country by the wide territory over which it must extend, to at all meet the requirements of the people.

Thirdly, the banking branch of the Post-Office Department could not be made self-sustaining, and at the same time pay a rate of interest that would draw deposits. It is not likely that 3½ per cent. would be satisfactory when there are perfectly sound banks that can pay five per cent.; and yet 3½ is probably more than the Department could afford to pay. Following the rule of the English system, and the only safe one, it must invest its deposits in Government securities, on which it cannot now realize more than four per cent. Out of the half per cent. margin must come all expenses and the loss of interest on unused balances. The Department could not even take the very necessary precaution of keeping a cash reserve against deposits, and though it may be said that the degree of confidence would be so great as to preclude a run, and so no reserve would be needed, it will be found that if the Government, through any of its departments, goes into banking, it will be amenable to the rules that govern banking operations. It could be readily shown, if space permitted, that the Department would be a constant dealer in bonds, buying on a high market, and selling on a low one—a process not conducive to profit—and it is highly probable that from these various causes the chronic deficit of the mail-service would be increased by the losses incurred in the banking department, a result which could not be defended on any tenable ground.

Next, as concerning State inspection. It is certainly remarkable that a system which has been tried so fully and failed so utterly, should still be so implicitly relied on; that men, who pride themselves on being practical, and who never fail to have their little fling at theorists, should cling to a theory that has broken down whenever tested.

Official examination has had a very thorough trial in this country; it has been a feature of the national banking system since its organization in 1864; the history of these banks has, as a whole, been creditable, but scores of them have failed, many disgracefully, and the worst of them in localities where it might be expected that the examinations would be most thorough; while the life-insurance companies and savings-banks of New York have long been objects of legislative solicitude and official care, with results that do not need to be told here.

The theory of State intervention in such matters is fallacious; private enterprise, if left to itself, would compass the desired end much better than any governmental machinery. The indorsement which the State gives to a new institution, by granting a charter and nominally assuming a supervisory control, endows it with an air of respectability and solidity which it could not otherwise command, and which is for the most part illusive. If depositors understood that their sole reliance was the character of the men they were dealing with, and that the only supervision would be such as they chose to exercise, they would soon come to select the guardians of their savings with greater care, and scan their acts more closely.

The State has a legitimate function which it has very imperfectly fulfilled in this connection; it *is* competent to enforce the performance of contracts; to visit punishment upon negligent or dishonest officials; to secure prompt and inexpensive justice to the sufferers in event of failures. This has not been done, but instead, contracts have been shamelessly broken with impunity; felony has been openly compounded; and

the proceedings of winding-up defunct banks have been dilatory and extravagant—conducted with a disregard of the interests of the depositors that differs from common swindling only in having the sanction of the courts. If the State had performed the duties which manifestly belong to it, there would be less clamor now for it to step out of its proper sphere to manage financial corporations.

It is true that the public has been marvelously credulous. Any adventurer who could raise money enough to put up a sign and make large promises would find some trusting fools to leave their money with him, and it almost seems that they should be protected against themselves; but efforts which aim to protect people from the consequences of their own folly, however amiable they may be, are rarely successful; it is best in the end to let people reap the reward of their stupidity.

Unfortunately, the average depositor in savings-banks labors under disadvantages in being without facilities for getting information or training which would help him to form an intelligent judgment on it when obtained; but this is one of the unpleasant concomitants of ignorance from which there is no way of escape except through the acquirement of knowledge. The public does not seem very apt in gaining this sort of knowledge; but only as it is mastered will a better condition of things be reached. The teachings of the last few years have been very thorough, and it is to be hoped that confidence will be more intelligently placed in the future than it has been in the recent past; that new candidates for it will find that more strenuous and legitimate measures are needed.

A good deal is said about the philanthropy of this class of institutions; but analysis would doubtless show that the altruistic element in them is the merest trace. They are formed by men who are selfish enough to desire to make them as large and prosperous as may be; it will not need a great prolongation of the present state of feeling to teach them that the way to success is to offer the highest guarantees of good management and security, and see to it that these guarantees be real.

As to the best methods of convincing the public of their trustworthiness, that may safely be left to the managers themselves; the utmost publicity and fullness in the statements of condition, and the greatest freedom for the inspection of accounts and securities by depositors, or those in their interest, would contribute much to that end.

LITERARY NOTICES.

THE QUESTION OF REST FOR WOMEN DURING MENSTRUATION. By MARY PUTNAM-JACOBI, M. D. The Boylston Prize Essay of Harvard University for 1876. Pp. 232. New York: G. P. Putnam's Sons, 1877. Price, $3.50.

IT is fortunate for that group of physiological and social conditions involved in what is termed the "Woman Question" that it has been investigated in one of its most important aspects by an author not only specially prepared by education and training to do it justice, but one, so to speak, "to the manner born." The motive of Dr. Putnam-Jacobi's book seems to be to close the discussion opened by Dr. Clarke in his "Sex in Education," rather than to make a direct answer to his argument That it does not close this discussion, and furnish an authoritative canon to measure the value of the "question of rest for women," is the fault partly of the material gathered, and partly of the method of handling the facts. There is no difficulty in the way of doctors, male or female, collecting facts relating to women sick; but, when facts are needed concerning women well, the innate delicacy of the sex is in arms against the statistician. This is evident when we state that, of 1,000 circulars calling for information regarding the sexual history of women in different occupations, but 268 were answered.

The second section of the book deals with the facts obtained in reply to this circular. These facts relate to the condition of health of childhood, and of parents or sisters; the age of going to and leaving school; the number of hours of study, of exercise; the nature of the study or occupation; pain during menstruation; the need and length of rest during the continuance of that function, and the time when rest first became necessary. The strength is measured by exercise, and several other conditions naturally suggested by the questions are given. These facts are tabulated under groups distinguished by either the total absence of pain or its presence at various periods. The author makes ingenious but legitimate use of her figures, hampered by the small number of individuals subjected to analysis. The number is sufficient, however, to foreshadow what is probably the amount of disability entailed upon women by the need of rest. Too much stress appears to be laid upon the mere presence of pain and the incapacity to work resulting from it, as if this were the only source of disability. Women are sometimes obliged to take rest from the nervous depression and mental disturbance which attend the exercise of the ovarian function; but it is possible that it is the better way, when the interpretation of the causes of incapacity is left to the average individual, that some well-understood term like "pain" be adopted. The section on statistics being long and complicated, we must overlook the steps of the process, and confine ourselves to the results.

Out of the number of women interrogated (286 cases), 94, or 35 per cent., declare themselves always free from discomfort (pain?) during menstruation; by adding to this number 46, who only suffered slightly, or occasionally during that period, this proportion is raised to 59 per cent.; on the other hand, 128 women, or 47 per cent., suffered seriously from pain; in them menstruation was, therefore, a morbid process. "In all such cases," remarks the author, "rest during the existence of such pain is as desirable as during the occurrence of any other." Of the 162 painful cases, including all degrees of pain, 53 per cent. had been so from the beginning; and in 47 per cent. the habit had been acquired. The relation of the age at which schooling began and the time spent in school to this catamenial pain is not very evident, as this condition is very nearly alike in all the groups. Of the painful group 18 per cent. received very little education, while in the normal group none are so specified. Of the first only eight per cent. pursued advanced studies beyond the age of twenty-two against 16 per cent. in the latter. Dr. Putnam-Jacobi is led to the conclusion from her figures, which are unfortunately too limited to afford even a guess at the real truth, that the highest education given to women is the most favorable to menstrual health; the least favorable being the ornamental education. In the matter of physical education, it was found that those who never suffered pain exercised more than the other class; but all classes were found to exercise too little during childhood and girlhood. The tables show that the family history exerts a greater influence over the menstrual life than occupation. The figures prove that two-thirds of those who suffered periodical pain inherited some special or general constitutional defect. Physical vigor, as measured by the capacity for exercise, was shown among those free from pain in the ability to walk an average of five miles; the average for those who habitually suffered pain was three and a quarter miles; and for the cases of slight or acquired pain four miles. "Capacity for exercise was nearly always in inverse proportion to the habit of pain." The tables show that persons without occupation suffered from painful menstruation in much larger proportion than those who were occupied. One would infer from this that the author, in a measure, traced this result to the want of occupation; while we should reverse the conditions of cause and effect, and explain the lack of occupation by the incapacity resulting from the periodical pain. The conclusion is also reached from the fact that marriage is opposed to the existence of habitual periodical pain. And, lastly, "as regards rest—the most important question for our purpose—we have seen that the above data do not suffice to inform us of its influence;" and thus, so far as the main theme of the book is concerned, the author leaves the "question of

rest for women" in just the condition in which she found it.

The third section, occupying fifty pages, is a review of the various theories of menstruation, and shows considerable research.

The next section is devoted to what the author calls experimental research upon six persons in the form of daily tabulated statements of pulse, temperature, dynamics, and the excretion of urea, before, after, and during ovulation. The general results to be gathered from the tables are, that excretion of urea is increased previous to the hæmorrhage over the usual amount, although there were many exceptions to this rule, individual peculiarities generally governing the results. The number of cases observed, however, was too small to afford conclusions. The same objection may be made against the dynamometer and temperature tests. Physiological experiments of this nature always require a sufficient number of subjects to reduce individual peculiarities and accidental conditions to a minimum in the mean results. The state of the circulation is given a very careful study by means of the sphygmograph before, during, and after menstruation, from which observations the author concludes that there is an increase in the tension of the arteries seven to nine days preceding menstruation, to be lowered, as a rule, a few hours after the beginning of the hæmorrhage, reaching its minimum after its cessation. This increase in intermenstrual arterial tension, being similar to that observed in pregnancy, leads the author to this remarkable conclusion—"that in all these respects the intermenstrual, and especially the premenstrual, period represents a pregnancy in miniature." From the facts gathered in this experimental chapter, "it should follow," the author says, "that reproduction in the human female is not intermittent, but incessant; not periodical, but rhythmic; not dependent on the volitions of animal life, but as involuntary and inevitable as are all the phenomena of nutritive life." From what we know of the author, we believe the phraseology of the above will be materially altered in the next edition. Aside from the unscientific use of words, and the strained meaning put upon the word *rhythmic*, the author confounds reproduction with the conditions essential to reproduction. It conflicts also with reasoning to which this is designed to be the natural conclusion. For instance, on page 98, speaking of the Graafian vesicles, she says that, "as the process of their development is gradual, the periods of rupture are necessarily intermittent;" and, as if to preclude all idea of rhythmic action, she says, further, it "is one of the most irregular of physiological phenomena."

We shall end our notice by a few remarks on the conclusions with which the author closes the book.

Menstrual pain, instead of being the result of want of rest, depends upon—1. "Imperfect power of resistance in the nerve-centres." This presupposes an inherent tendency to pain in all women during this act, its expression depending on the power of repression, although this alternative is evaded by the author. 2. Organic defects; and, lastly, acquired pain, which may depend upon conditions common to both sexes in the genesis of disease; upon causes mainly due to parturition, and thus peculiar to women; or "from two causes, very much more frequently operative in women than men, namely, ill-arranged work and celibacy." Whether this work is "ill-arranged" with reference to time or not, the author does not inform us. The conclusion is natural that this ill-arrangement is due to the need of intervals of rest, since work and rest are natural antitheses. The evil effects of celibacy are insisted upon in several places. The author even rises to the heights of impassioned prose, when she says that "many others never obtain the opportunity to bear a single child, for which, nevertheless, every fibre of their physical and moral being is yearning." While we cannot express ourselves so poetically, we concur in the idea; but it is not a little singular that, since the motive of the book is to demonstrate woman's capacity for continuous work during certain periods, the derangements due to matrimony receive no attention. The fifth and last conclusion is that "there is nothing in the nature of menstruation to imply the necessity, or even the desirability, of rest for women whose nutrition is really normal." Yet, upon the previous page, in speaking

of the presence of pain in 46 per cent. of women, it is traced among other things to "work that is either absolutely excessive, or excessive relative to woman's constitution, by being prolonged too much during a single session, or else which is insufficiently relieved by recreation." It is impossible to read this last section of the book without coming to the conclusion that the author in many instances is reasoning against her convictions.

The author does not seek to evade the fact that 46 per cent. of women suffer a greater or less degree of pain during this time, and yet it has not the slightest bearing upon woman's efficiency to work while thus suffering to say, as the author does, that this pain is not directly dependent upon the need of rest. If we recognize in pain the ideal curse of humanity, we may form a notion of what a woman must undergo who, under the lash of necessity or duty, carries her burden of pain to her daily tasks. It matters not whether the pain is evaded, or mitigated or not by rest, it is a panacea instinctively sought. It accords also with the universal experience of medical men that pelvic pain, or hyperæmia, is quieted by rest, and this is as true of menstrual pain as of any other condition. Such a fact as this cannot be reasoned away by arguments drawn from speculative physiology.

But we must recognize in this book a new departure in the literature of the question. It is something new, as well as a grand stride in the right direction, for the advocates of woman's immunity from anything like physical restraints to labor to investigate facts and to couch this investigation in scientific language. The faults of the book are mainly those of hasty preparation, both in the collection of data and the arguments based upon them. We are satisfied that, with a wider range of facts and greater deliberation in handling them, many of the hasty generalizations which we have pointed out would not have occurred. The book shows hard and honest work, and demonstrates the great capacity of Dr. Putnam-Jacobi for scientific investigation.

FIFTEEN-CENT DINNERS FOR WORKING-MEN'S FAMILIES. By JULIET CORSON. Pp. 40.

THIS little tract is designed to show the working-man's wife how she may provide for her household a sufficiency of good, wholesome food at a cost easily within the means of the poorly-paid day-laborer. An edition of 50,000 copies has been published by the author for gratuitous distribution, and it would be an act of humanity to aid in circulating the book among the class who have need of the information it contains. The poorer class of people are, in proportion to their means, far more wasteful than the rich, and the information here conveyed cannot fail to be highly profitable to them.

REPORT ON THE TELEGRAPHIC DETERMINATION OF DIFFERENCES OF LONGITUDE IN THE WEST INDIES AND CENTRAL AMERICA. By Lieutenant-Commander F. M. GREEN, U. S. Navy. Washington: Government Printing-Office, 1877.

NAVIGATORS, geographers, and others, are constantly demanding improved values of the geographical coördinates of places on the earth's surface, as the demands of their pursuits become more and more exacting. When the longitude of a slow-sailing vessel was obtained by observations of lunar distances a large uncertainty in the resulting datum was inevitable, and was expected and allowed for. Modern practice in steamers, where every additional hour's run means the expenditure of valuable fuel, etc., and where an uncertainty as to the ship's position is subsequently paid for by the owner in the expenses of the voyage, demands something more than the approximate longitudes of prominent seaports, which before were sufficient.

This want has been long felt, and the establishment of secondary meridians has been attempted in many places and by various nations. In 1866 a committee of the French Bureau des Longitudes was directed to prepare a plan for fixing a certain number of fundamental secondary meridians, separated by convenient distances, all round the world; and, in March, 1867, their report having been submitted to the Minister of Marine, its immediate execution was directed. A commission of eminent French naval officers was organized to superintend the preparation for this work and its performance, and five or six parties of skilful observers were, after several months of preliminary study and practice, dispatched with their instruments to various parts of the world to make observations of moon-culmintaions to

determine the difference of longitude between their respective stations and the meridian of Paris. At that time, the present wide extension of submarine cables could not be foreseen. This commission fixed several points in the West Indies, and from these longitudes were counted by French and other navigators. Other points in this region were established by other nations; and frequent discrepancies arose, for which there was no remedy, except an entirely new and independent determination by the accurate method of telegraphic longitudes.

In view of the importance of the commerce of the United States with the West Indies, the Hydrographer of the U. S. Navy determined to undertake this task, and accordingly a plan for its completion was prepared and the execution of this plan was confided to Lieutenant-Commander Green. This plan was very comprehensive, and included the determination of the latitude of each of the following stations, together with its longitude from the U. S. Naval observatory of Washington, which was already telegraphically connected with Greenwich.

The stations selected were: 1. Key West; 2. Havana; 3. Santiago de Cuba; 4. Kingston (Jamaica); 5. Aspinwall; 6. Panama; 7. San Juan (Porto Rico); 8. St. Thomas; 9. St. Croix; 10. St. Johns (Antigua); 11. St. Pierre (Martinique); 12. Bridgetown (Barbados); 13. Port Spain (Trinidad).

Station 1 was already connected with Washington through the labors of the Coast Survey. It is to be noted that stations 2 and 3 furnish a basis for an accurate survey of Cuba, that 5 and 6 furnish starting-points for the whole sea-coast of Mexico and Central America, and that 6, in connection with the longitude of Santiago de Chile (already determined in position by two American astronomers, Gilliss and Gould), will furnish a basis for the survey of the west coast of South America. The north coast of South America is fixed by the stations 5 and 13 (already the Hydrographic Office has published the results of chronometer expeditions, between these points, made under its direction by Commander Ryan, U. S. N., in 1877). On station 8 many longitudes, previously determined, depend; and the other stations amply suffice to fix the Windward and Virgin Islands. Thus the comprehensive plan of the expedition, together with that of the expedition sent out by the Hydrographic Office in 1877, under the same distinguished officer, will practically suffice to fix nearly the whole eastern and northern sea-coast of South America, and will furnish bases for the establishment of the coast-line of Mexico and much of the West coast of the Southern Continent. The expedition of 1877 contemplates the junction of station 13 with Lisbon, Madeira, Cape Verd, Para, Rio, Montevideo, and Buenos Ayres.

The work necessary to the final fixing of the positions of these thirteen stations was done in 1874–'76, and is described in detail in the report before us.

Full descriptions of the instruments (with plates), the methods of observation and reduction, etc., are given in this volume, to which we refer for particulars which would be out of place here. Suffice it to say that the results are of the same grade of excellence as those attained in similar work of the highest class all over the world. A special point of excellence is the absolute uniformity of programme at each of the stations in each of the expeditions, and this contributed in no small degree to the excellence of the results. This expedition reflects great credit upon the navy and upon all concerned in its planning and execution, and is especially noteworthy as being the first expedition of the kind undertaken by naval officers of any country in foreign ports. It is to be hoped that this important service to navigation and geography will be followed by other similar work hardly less needed.

INFLUENCE OF CIVILIZATION ON DURATION OF LIFE. By CHARLTON I. LEWIS. A Discourse at the Annual Meeting of the American Public Health Association, October, 1876. Cambridge: Riverside Press.

THE doctrine of the survival of the fittest is now widely recognized as the key to all progress toward the perpetuation and perfection of the species, at least so far as the lower orders are concerned, and up to a certain point in the development of humanity.

But with the foundation of societies an opposite doctrine has been introduced. Instead of the pitiless destruction of the weak and the infirm, which marks the operations

of the law of natural selection, they are fostered, cared for, and allowed to propagate their kind. "Society preserves for the progenitors of the future alike the weak, the strong, the diseased, and the healthy. If, then, this blind law of natural selection is the one key to progress, man must degenerate." One school of statistical writers maintains that this result does actually appear.

But Mr. Lewis shows conclusively that, while "civilization does largely sacrifice one principle of progress — the law of evolution by survivorship — it introduces another still more potent principle"— longevity. The outcome of careful breeding for a few generations, with a view to improvement in this direction, would produce a people who would live to a patriarchal age. The idea of such stirpiculture as this is repulsive to our present habits of thought. It is probable that the idea will never be realized, but there is a tendency toward something of that kind.

Mr. Lewis truly says that the subject leads us to the door of a world of restless thought and speculation.

The paper is extremely interesting and suggestive.

ELEMENTARY LESSONS IN PHYSICAL GEOGRAPHY. By ARCHIBALD GEIKIE, LL. D., F. R. S. London and New York: Macmillan & Co., 1877. Pp. 375. Price, $1.75.

ONE of the best of the "Science Primer Series" was that of Dr. Geikie on "Physical Geography," which in the present volume is expanded into the form of a text-book for rather more advanced scholars.

The author is undoubted authority on this subject, and may be fully trusted, and his material is well arranged for the purposes of teaching. The illustrations are taken close at hand, and not only show the way in which effects, with which we are familiar, have been produced, but teach the collateral lesson that Nature's processes are uniform; that the most stupendous results of far-away lands or past time have been wrought by the same methods that are in operation here and now. This is a lesson that scientific men were slow to learn, and it has not hitherto been sufficiently taught in our text-books. It is something gained when a boy, watching the little streams of a summer shower making their way through a sand-bank, knows that he is looking on the same forces at work that make and waste a continent.

The book is freely illustrated with good woodcuts, and with maps showing the distribution of atmospheric pressure, temperature, volcanoes and earthquakes, ocean-currents, etc.

GEOLOGICAL AND GEOGRAPHICAL SURVEY OF COLORADO AND ADJACENT TERRITORY (1875). Pp. 834. Washington: Government Printing-Office.

IT would be impossible, within the narrow compass of a book-notice, to summarize the contents of this valuable report; indeed, the space at our disposal would be insufficient even to give a simple list of the many wonderful natural curiosities and interesting ancient ruins here for the first time described and pictured. Then, in addition to the reports of the geologists and togpographers, we have an elaborate monograph on the American bison, by J. A. Allen; and a voluminous report by Dr. A. S. Packard, Jr., on the Rocky Mountain locust and other insects injurious to the field and garden crops of the Western Territories.

FUR-BEARING ANIMALS. By ELLIOTT COUES. Pp. 362. With numerous Figures and Plates. Washington: Government Printing-Office.

DR. COUES has for some time been engaged in preparing a systematic history of the North American mammals, both living and extinct, and the present volume is offered as a specimen of the method of treatment to be adopted in that work. The group of animal forms described in this monograph, the family *Mustelidæ*, he divides into five sub-families, namely, *Mustelinæ* (wolverene, marten, weasel), *Mephitinæ* (skunk), *Melinæ* (badger), *Lutrinæ* (otter), *Enhydrinæ* (sea-otter). The material on which the author bases his systematic classification is sufficiently voluminous, namely, the collections made by Hayden's Survey, of which he is the naturalist, and those of the National Museum at Washington. The purely scientific and technical aspects of the subject-matter are, of course, discussed

with all requisite detail, and there is no doubt that the work will be prized by naturalists as a substantial contribution to zoölogical science. But, at the same time, the interests of a larger circle, viz., the educated though unscientific public, have not been overlooked. Indeed, what may be called the "popular" aspects of the subject in hand, namely, the life-histories of the species, and their economic and other practical relations, are considered at length.

NARRATIVE OF THE EXPEDITION OF THE POLARIS. Edited by Rear-Admiral C. H. DAVIS. Pp. 696. Washington: Government Printing-Office.

THE story of the gallant Captain Charles Francis Hall is here told in simple, unaffected style; indeed, as it would appear, for the most part in the very words of Hall himself, and of his companions in danger and misfortune. The volume is of quarto size, on heavy calendered paper, elegantly printed, and adorned with a steel-plate portrait of Captain Hall, a vignette of the Polaris, some forty full-page wood engravings, numerous smaller engravings, and six maps. It is, indeed, a fitting monument to the genius and intrepidity of Captain Hall and the modest heroism of his officers and crew.

PUBLICATIONS RECEIVED.

Natural Law. By Edith Simcox. Boston: Osgood. Pp. 378

History of the Ottoman Turks. By Sir E. S. Creasy. New York: Holt & Co. Pp. 574. $2.50.

The World's Progress. G. P. Putnam, editor. New York: Putnam's Sons. Pp. 1028. $4.50.

Freethinking and Plain Speaking. By Leslie Stephen. New York: Putnam's Sons. Pp. 362. $2.50.

Outlines of Modern Chemistry. By C. Gilbert Wheeler. New York: A. S. Barnes & Co. Pp. 231. $1.75.

History of Materialism. By F. A. Lange. Boston: Osgood & Co. Vol. I., pp. 350.

Through Rome On. By Nathaniel R. Waters. New York: C. P. Somerby. Pp. 352. $1.75.

The Religious Feeling. By Newman Smyth. New York: Scribner, Armstrong & Co. Pp. 171. $1.25.

Our Common Insects. By A. S. Packard, Jr. Boston: Estes & Lauriat. Pp. 225. $1.50.

Tables for the Determination of Minerals. By Persifor Frazer, Jr. Philadelphia: Lippincott & Co. Pp. 119. $2.

Smithsonian Report for 1876. Washington: Government Printing-Office. Pp. 488.

Village Improvements and Farm Villages. By George E. Waring, Jr. Boston: Osgood & Co. Pp. 200. 75 cents.

Steam-Engineering. By J. W. Nystrom. New York: Putnam's Sons. Pp. 185. $2.50.

Browne's Phonographic Monthly. New York: D. L. Scott-Browne. Vol. I., pp. 144. $2 a year.

Chemistry: Theoretical, Practical, and Analytical. Parts 21-25. Philadelphia: Lippincott & Co. 50 cents each.

Metallurgical Review. New York: D. Williams. Vol. I., No. 2, pp. 96. $5 a year.

Report of Steamboat Inspection in Canada. Ottawa: Maclean, Rogers & Co. print. Pp. 346.

Anales del Museo Nacional de México, tom. I., entrega 1ª. México: Cárlos Ramiro print. Pp. 46. With Plate.

Catalogue of the Missouri State University. Jefferson City: Regan & Carter print. Pp. 160.

Preservation of Wood as adapted to Shipbuilding. By C. E. Munroe. Claremont, N. H.: Manufacturing Co. print. Pp. 16.

Immediate Fulfillment of Prophecy. By Captain J. E. Cole. New York: O'Keefe print. Pp. 53.

Proceedings of the American Philological Association. Hartford: Case, Lockwood & Brainard Co. print. Pp. 52.

Latimer Collection of Antiquities. By O. T. Mason. From "Smithsonian Report for 1876."

Immortality of the Soul. By C. Skelton, M.D. Trenton, N. J.: Naar, Day & Naar print. Pp. 27.

Overturning the World. By Dr. G. M. Ramsey. New York: P. F. McBreen print. Pp. 27.

Iodates of Cobalt and Nickel. By F. W. Clarke. From *American Journal of Science.* Pp. 7.

Calendar of the University of Minnesota. Minneapolis: The University. Pp. 104.

International Conference on Education. Washington: Government Printing-Office. Pp. 92.

The Membrana Tympani as a Phonautograph. New York: W. Wood & Co. With Heliotype. Pp. 6.

Meteorological Researches for the Use of Coast Pilots. Part I. With Charts. Washington: Government Printing-Office. Pp. 49.

Should Comparative Anatomy be included in a Medical Course? By Dr. B. G. Wilder. New York: Appletons. Pp. 35.

Four Great Eras in Modern Astronomy. By Jacob Ennis. Cambridge: Wilson & Son print. Pp. 21.

The Force that put all the Heavens in Motion. By Jacob Ennis. Pp. 23.

Standard Public Time. By Jacob Ennis. Cambridge: Printed for the Observatory. Pp. 12.

Official Circular No. 8 of Johns Hopkins University. Pp. 12.

Cable-making and Suspension Bridges. By W. Hildenbrand. New York: Van Nostrand. Pp. 121. 50 cents.

POPULAR MISCELLANY.

The United States Pharmacopœia, as is well known, has been issued in revised editions every ten years, since its first appearance in 1830. These revisions have been made under the authority and direction of "the National Convention for revising the Pharmacopœia," consisting of delegates from medical and pharmaceutical colleges; the real work, however, has

mainly rested in the hands of a few persons, who have at the same time published the very remunerative "Dispensatory of the United States." The fifth edition of the United States Pharmacopœia, issued three years after the convention met in 1873, did not, however, meet with the former approval, and was left without its customary commentary, inasmuch as the authors of the Dispensatory failed to prepare in time a new edition supplementing the new Pharmacopœia. Suggestions for an earlier revision of the Pharmacopœia than in 1880 have since been advanced; and a new departure advocated in the method and scope of the revision. Dr. Edward R. Squibb, of Brooklyn, submitted to the American Medical Association an elaborate plan for a new and completer work, to be prepared by experts, under the control of that Association. This plan, however, was abruptly rejected by the American Medical Association at its recent meeting in Chicago, mainly on the ground that the work of pharmacopœial revision is not appropriate to that body. The American Pharmaceutical Association, too, of which Dr. Squibb is also a member, and to which his plan had been presented, objected to it on account of the unequal share accorded to pharmacy in the management of the work.

The plan to obtain a better Pharmacopœia at an earlier date, and under new management, would practically have failed for the present, if it were not for the judicious and prompt action and energy of Dr. Frederick Hoffmann, of New York, who carried the subject, when dropped by Dr. Squibb, into the American Pharmaceutical Association at its recent annual meeting at Toronto. He offered the resolution, that the American Pharmaceutical Association elect a Committee to prepare a complete Pharmacopœia which may be submitted to the criticism of the medical and pharmaceutical professions, and may be proposed to the above-mentioned National Convention for revising the Pharmacopœia. This resolution passed unanimously; and the result was, that a committee was appointed for this purpose, which has agreed upon a plan of its work and has selected the experts to accomplish it. Dr. Hoffmann, of New York, has taken charge of the chemical part of the new Pharmacopœia, Prof. Maisch, of Philadelphia, of the department of pharmacognosy; and Mr. Rice, of New York, represents pharmacy. This committee has promptly entered upon its labors, and expects to submit the results to the American Pharmaceutical Association in the fall of 1879. It remains to be seen whether the Association will then present the work of its expert-committee to the National Convention, supposed to meet in 1880; and whether the latter will accept this gratuitous offer: or else, whether the American Pharmaceutical Association, encouraged by the character and value of the work, and by the sentiments of its members and the profession at large, will choose independently to publish its Pharmacopœia. By such action it would realize a desideratum which Dr. Squibb vainly aimed to accomplish, and would relieve the profession from the old National Convention for revision of the Pharmacopœia, and this itself from any further labors, by presenting in time a new and adequate standard which by its intrinsic merits might at once command the approval and acceptance of the professions.

Salicylic Acid as a Remedy for Rheumatism.—The value of salicylic acid as a medicine in the treatment of rheumatism has been under discussion for some time, the weight of authority plainly inclining toward an affirmative solution of the problem. As a specimen of the favorable results obtained by the use of the drug, we quote the observations of Dr. L. P. Yandell, Jr., as stated in his "Report on Materia Medica" to the Kentucky State Medical Society. Dr. Yandell's report treats of a number of recently-introduced drugs; it is published in the *Louisville Medical News*. His experience with salicylic acid may be briefly stated as follows: First, in the City Hospital of Louisville, nine cases of acute articular rheumatism were treated with this drug, and a "perfect cure" effected; in every instance the disease was arrested within three days, and in several cases relief was obtained in from eight to twelve hours. The drug did not appear to have any antipyretic effect. The patients took the acid in ten and twenty grain doses, in

capsules, at varying intervals. In the same hospital three cases of chronic rheumatism were treated with salicylic acid without any good results. In his private practice Dr. Yandell has used this drug in five pronounced cases of acute rheumatism with entire success; and in another case this drug, combined with quinine, broke up the disease. The author writes that salicylic acid is best given in milk; it gives the milk a sweetish-sourish taste; a little tickling and sense of slight constriction may be felt about the throat, and an insignificant cough is not uncommon. He adds: "Salicylic acid is the first and only remedy that has proved itself at all reliable in the control of acute rheumatism in my hands. Salicylate of soda has shown no superiority over salicylic acid."

Notes on Fish-culture.—The one great difficulty met with in hatching the striped bass is, according to an intelligent correspondent of *Forest and Stream*, the fact that spawners of this species are very rarely found. About four years ago, we are informed, a few ripe "rock-fish" (striped bass) were found in the Roanoke River, North Carolina, and about 100,000 young fish were hatched from their spawn. One reason assigned for the diminution of this fish is the fact that they are marketed before they reach maturity. Prof. Baird favors the enactment of a law prohibitng the marketing of these fish when less than twelve inches long. Striped bass frequently attain a weight of sixty and eighty pounds; and it has been held that they do not spawn until they attain a weight of about twenty pounds. The same correspondent cites, as an evidence of the success of salmon-propagation, the recent capture of a nine-pound salmon in the Delaware. The fish was a California salmon—a variety with which the Delaware, Potomac, Susquehanna, and other rivers, were supplied a few years ago. It is supposed they return in five or six years, though difference in the temperature of the water, currents, and other conditions, may accelerate or retard the return. Over 400,000 eggs of California salmon were shipped last fall to New Zealand, where they nearly all arrived in excellent condition.

Florida Lizards.—During a sojourn in Waldo, Florida, Mr. Henry Gillman has studied the characters and habits of a great variety of lizards, and, in a brief communication to the *American Naturalist*, states some of the results of his observations. One point which he has been enabled to determine is the possession by the lizards of Florida of the power of "chameleonization," or of changing color. The author states positively that the lizards of Florida possess this power in a remarkable degree. Thus, he has seen a small, yellowish-brown lizard, on quitting the ground, instantly assume the dull gray-hue of a weather-beaten fence-rail, along which it glided. Passing under some olive-tinted foliage, it next adopted that color, which was succeeded by a bright green, as the animal reached and rested under the grass and leaves of like shade. The original yellowish-brown color was again assumed on the lizard returning to the ground. Each of these changes was almost instantaneous, and the entire series could not have occupied much more than one-quarter of a minute of time.

International Scientific Service.—Of Prof. Grote's paper, mentioned in our October number, on an International Scientific Congress, and read at the meeting of the American Association, we find a very good abstract in the *Polytechnic Review*, from which journal we quote the essential points of the paper. The author referred to the excellent work done by national scientific associations, such as the British Association and the American Association, but said that there is urgent need of a still broader organization—of an international congress of scientific men. Foremost among the problems which Science is striving to solve is that of the origin of our species. The elucidation of this question concerns the whole race, and no merely national organization possesses the means of exploring the whole field. Then, the various scientific explorations in Africa, Australia, and the polar regions, need coöperative assistance to realize the best results from the outlays, while the new knowledge they bring is the common inheritance of all enlightened nations. Now, where all participate all should contribute. Prof. Grote's plan of an inter-

national scientific service contemplates the appointment of commissioners by the civil governments of the world. The deliberations of this body "would be the wisdom of the age; its recommendations would be respected by the legislative powers of the consenting and represented nations. Under its auspices all extra-limital astronomical, geological, and biological expenditures would be fitted out, and directed to those places which would be most fruitful for any particular purpose. The difference in the mental faculties between different nations would prevent the loss in such a body of any possible suggestion which the human mind could offer."

At the same meeting a paper was read by Profs. Grote and Pitt on new fossils in the collection of the Buffalo Society of Natural Sciences, from the water-line group. The free ramus of the chelate appendage of *Pterygotus Cummingsi* (G. and P.) was described by the aid of drawings. The crab-like animal was over five feet in length, and lived in the shallow waters of the Silurian sea where Buffalo now stands. Its remains were deposited in the sedimentary lime-beds which are now being worked for manufacturing purposes.

Prof. Loomis on Rain-Areas. — The *American Journal of Science* for July contains the seventh paper of a series by Prof. Loomis, in which he investigates the phenomena of storms, their origin, development, and movements. It was shown in a previous paper that the form of a rain-area, that is, of a storm moving over the country, is usually elliptical: this elongated form is more obvious in storms which move along the coast than in those which move farther inland. The area of low barometer in a storm is not at the centre of greatest rainfall. Sometimes the rain centre is northward, or southward, or eastward, or westward, of the area of low barometer. North of latitude 36° the distance of the area of greatest rainfall from the centre of low pressure is in a majority of cases less than 250 miles, but in some instances three times that distance, the average being 300 miles. When extensive rainfalls occur there is a marked tendency to the formation of several centres of precipitation, and heavy rains may occur at various localities in a storm-area. This fact suggests that during the progress of a storm there occur local causes of great precipitation.

The tables show that heavy rainfalls are not of long duration over extended areas, and the conclusion from this fact is, that the causes which produce rain do not increase in force from the rainfall, but diminish and become exhausted. This result cannot be attributed to a want of supply of vapor, as the inflowing winds continually carry vapor into the storm-area, and this is especially true in the case of storms moving along the Atlantic border. What seems to be implied is, that an exhaustion occurs of the forces which impart that movement to the air requisite to precipitation.

The centre of great rain-areas occurs along the Atlantic border four times more frequently than inland, nor is this general fact changed in the region of the Great Lakes. Very extensive rainfalls are most frequent in autumn and winter, and occur most frequently in mornings and afternoons, and are least frequent during evenings, the difference in this respect being very marked. It is observed, too, that the "heaviest rainfalls are seldom accompanied by very high winds."

"There seems," says Prof. Loomis, "no room to doubt that areas of low barometer occur during periods of twenty-four hours with little or no rain, and travel nearly eastward with an average velocity of about twenty miles an hour." From this fact it is concluded that rainfall is not essential to the formation of areas of low barometer, and is not the principal cause of their formation nor of their progressive motion. The barometer is frequently low during the hazy weather of October, when the Indian summer prevails, a period usually of little rainfall.

Taste-Perceptions.—An interesting inquiry has been made by Vintschgau and Höingschmied to determine how much time is requisite to perceive different taste-sensations. We have already, in No. 39 of the MONTHLY, given the results obtained by these investigators in their earlier researches; but since then they have studied the subject more thoroughly, attacking

more complex problems, as will be seen from the following account of their labors, which we take from the *English Mechanic*. In these experiments by pressure of a brush saturated with a concentrated solution of a savory substance on the tongue, an electric circuit was closed, which was only opened by the person when he made a signal on first perceiving the taste. The time during which the current flowed was marked by a rotating cylinder, and represented the "reaction-time" of a given taste. First, the "reaction-time" of four different substances was ascertained. This experiment was then so modified that not merely the sensation of taste had to be answered to, but the tongue of the person was touched now with water, now with a savory solution, without his knowing beforehand which was to be applied; he had to decide which had touched his tongue, and gave the signal only when it was the savory matter. In a final series of experiments there were always two savory substances used: when the person perceived the one, he gave the signal with one hand; when he perceived the other, with the other hand. Here the person had not only to perceive the sensation, but to distinguish the one taste from the other, and then to make the right choice of the hand to give the signal. The results are stated in the table below, where the first vertical series gives the names of the savory substances; the second, the time in seconds between the application of the substance and giving of the signal; the third, the reaction-time when the savory substance was applied interchangeably with water, and must be distinguished from this; the fourth, fifth, sixth, and seventh, the reaction-time in comparison with common salt, acid, sugar, and quinine, respectively:

SUBSTANCES.	Simple Sensation.	COMPARISON WITH				
		Water.	Salt.	Acid.	Sugar.	Quinine
Comm'n salt...	0.1598	0.2766	.....	0.3838	0.3878	0.4804
Acid....	0.1676	0.3315	0.3749	.....	0.4081	0.4096
Sugar...	0.1639	0.3840	0.3688	0.4878	.....	0.4224
Quinine.	0.2196	0.4129	0.4388	0.5095	0.4210	.....

"If we take as a basis," say the authors, "the reaction-times when the tongue was touched with a savory substance alone, and compare therewith the reaction-times which were obtained in the experiments whether with water, or with another savory substance, we find that the following law generally holds: If we experiment with distilled water and a savory substance, or interchangeably with two savory substances on the tongue-tip, then the time of recognition of the one (in experiments with water), or of the two (in experiments with savory substances), is longer, the longer the reaction-time of one of the savory substances on simple application." The converse of this law, however (which is only in general valid), does not hold good.

An Underground Pneumatic Clock-Regulator.—The inhabitants of modern cities who are accustomed to receive their supply of water and illuminating gas through pipes laid under the streets, and who are prepared to welcome the introduction of a system of steam-heating on a large scale, will next "get the time of day" from underground pipes. A plan of regulating clocks by means of compressed air has been devised by an Austrian engineer named Mayrhofer. Its principle will be understood from the following description, which we take from the *Boston Journal of Chemistry:* In the first place, tubes are laid to convey compressed air from a central station, in which is the "master-clock." A simple contrivance, connected with the tubes and the clock, lets off a puff of air every minute or half-minute, and the fingers of all the clocks in the system are in that manner pushed forward with unerring accuracy, in accordance with the time indicated by the standard timepieces in the observatory, so that exact uniformity can be maintained without difficulty in the time shown on any number of dials. The weather has no effect on the air, so far as the working of the pneumatic clocks is concerned, and, be it hot or be it cold, the little valve lets off its puff of air, and the clocks go accurately, in defiance of atmospherical influences. A small yearly charge is made for the clocks, and there is no further expense or trouble. The system has been in operation in Vienna for nearly four months, and has worked without a solitary hitch, so that the people are beginning to realize the idea that time can be "laid on" in their houses as readily as either water or gas.

Local Temperatures of the Blood.—From researches made by Claude Bernard, it appears that while the temperature of the blood in the aorta and its more important branches is uniform, that of the venous blood varies considerably in different regions of the inferior vena cava and its principal tributaries. At the junction of the extremities and the neck with the trunk of the body, the venous blood is colder than that in the great arteries; in the right heart it is considerably hotter. If we determine its temperature at successive points in the inferior cava, we find that at the junction of the iliac veins this is lower than the arterial temperature: on a level with the entrance of the renal veins, the two are about equal; on a level with the hepatic veins, the temperature of the venous exceeds that of the arterial blood by nine-tenths of a degree. It retains this superiority even after it has become mixed in the right heart with the colder blood returned through the superior cava. Accordingly, though the venous blood of the peripheral parts is colder than in the arteries, it acquires sufficient heat during its passage through the abdominal cavity, not merely to equalize the difference, but actually to give it a permanent advantage. This is so, not because the viscera are the source of animal heat, but simply because they are by their situation protected from the effects of radiation and evaporation. Heat is generated in all the tissues, muscles, nerves, nerve-centres, and glands. The rise of temperature, which may always be detected in a muscle when thrown into a state of contraction, is invariably preceded by a slight depression; and precisely the same phenomenon is exhibited by a gland when its secretory nerve is stimulated.

Electro-Plating.—We take from Van Nostrand's *Engineering Magazine* the following statement of the results obtained by Bertrand in experiments in electro-plating with aluminium, magnesium, cadmium, bismuth, antimony, and palladium. Aluminium was deposited on decomposing, with a strong battery a solution of the double chloride of aluminium and ammonium; a plate of copper forming the negative pole whitens gradually, and becomes covered with a layer of aluminium, which takes a good polish. The double chloride of magnesium and ammonium in an aqueous solution is readily decomposed by the battery, giving in a few minutes strongly-adherent and homogeneous deposits of magnesium on a sheet of copper. It polishes readily. The battery must be powerful. Cadmium is best deposited from the bromide to which a little sulphuric acid has been added; it is then very coherent and very white, and takes a fine polish. The sulphate, if acidulated, also gives an immediate deposit of metallic cadmium, very adhesive and capable of a good polish. Bismuth is deposited from a solution of the double chloride of bismuth and ammonium on copper or brass by the current from a Bunsen element; it is very adhesive, and might be used in decorating works of art. Antimony can be deposited from a solution of the double chloride of antimony and ammonium at common temperatures. Deposits of palladium are obtained with ease by means of the double chloride of palladium and ammonium, either with or without the battery. The solution must be perfectly neutral.

New Method of Artificial Respiration.—Dr. Benjamin Howard, late of the Long Island Medical College, recently gave at King's College Hospital, London, a demonstration of his "direct method" of producing artificial respiration. For the purpose of making his description of the method perfectly plain, Dr. Howard had a man to act the part of a person rescued from the water, and apparently dead from drowning. The first thing done was to rip away the wet clothing to the waist, making of it a large, firm bolster. "Quickly turning the face downward," said he, as he proceeded to explain the process, "the bolster beneath the epigastrium, making that the highest point, the mouth the lowest; placing both hands on his back immediately above the bolster, my whole weight is thrown forcibly forward, compressing the stomach and lower part of the chest between my hands and the bolster for a few seconds, two or three times, with very short intervals." Thus the lungs are relieved of water and the stomach emptied. Then "quickly turn the patient on his back, the bolster again making the epigastrium

and anterior margins of the costal cartilages the highest point of the body, the shoulders and occiput barely resting on the ground. Seize the patient's wrists, and, having secured the utmost possible extension of them behind his head, hold them fast to the ground with your left hand. With a dry pocket-handkerchief between the right thumb and forefinger withdraw the tongue, holding it at the extreme right corner of the mouth. If a boy be at hand, both wrists and tongue may be confided to his care. In this position two-thirds of the entrance to the mouth is free and the tongue is immovably fixed forward; the epiglottis is precluded from pressure and partial closure; the head is dependent; the free margins of the costal cartilages are prominent, and there is a high degree of fixed thoracic expansion. The epigastrium being highest, the movements of the diaphragm are not embarrassed by the abdominal viscera.

"To produce respiration, you kneel astride the patient's hips, rest the ball of each thumb on the corresponding costoxyphoid ligaments, the fingers falling into the lower intercostal spaces; now, resting your elbows against your sides, and using your knees as a pivot, throw the whole weight of your body slowly and steadily forward until your mouth nearly touches that of the patient, and while you slowly count three; then *suddenly* spring back to your first position on your knees, remain there while you might slowly count two; then repeat, and so on about eight or ten times a minute." The acting patient at the very first steps of the process gasped involuntarily, and as it was continued he came more and more under the control of the operator. After the operation had ceased, there were visible successive waves of involuntary respiration which the "patient" could not control.

Frank Buckland on the Berlin Gorilla.—Mr. Frank Buckland has made a visit to "Pongo," the young gorilla at the Westminster Aquarium, and observed with much pleasure the many great differences between monkey and man. First he notes the hands of the gorilla: the thumb, he observes, is exceedingly short, and "cannot be used with anything like the facility as in the human subject." Then, in the gorilla, the spaces from the knuckles to the first joint of the finger are united by a membrane, and become practically a continuation of the palm. The gorilla, too, uses its hand much more as a foot than as a hand. "The thumb of the foot," he adds, "has great powers of prehension; indeed, it may be said that the thumb proper is carried on the foot. The gorilla has no calf to the leg, and no biceps in the forearm: he cannot stand upright without supporting himself by means of some object. The back of the gorilla is almost square, something after the form of the flat saddle used in equestrian feats in circuses. The cause of this is, that the ribs come close down on the top of the hip-bone." So far as Mr. Buckland has been able to learn, the gorilla does not use a stick for the purpose of striking, neither does he ever strike with his hands. Two children, a boy and a girl, were permitted to play with Pongo, and as Mr. Buckland looked on he "could not help seeing what a vast line the Creator had drawn between them." Our author concludes by saying that Pongo's structure and manners confirm the idea that Darwin is wrong, and that human beings are not monkeys. This doctrine of the identity of man and monkey gives Mr. Buckland a great deal of trouble, and from the vehemence with which he combats it one is led to suppose that it must be prevalent in England. It is a little strange, however, that the adepts of this vile heresy have contrived to mask their teachings, for we have not seen this doctrine upheld in any of the publications of the day. Mr. Buckland asks: "Why not rest satisfied with the origin of our race thus revealed to us by the great Creator himself?—'So God created man in his own image, and in the image of God created he him; male and female created he them.'"

Topographical Surveys and Health.—Mr. James T. Gardner delivered, at the Boston meeting of the Public Health Association, an address on the "Relation between Topographical Surveys and the Study of Public Health," which abounds in suggestions of the highest practical importance. As an illustration of the author's mode of enforcing his arguments, we may take his remarks on "natural drainage." "This," we

are informed, "results from combined action of configuration, character of soil, constitution of underlying rock, and the form of its surface. These four elements regulate natural drainage. Each must present favorable conditions, or deadly waters will accumulate on the surface or in hidden strata. *No plan of artificial drainage can be completely successful unless based on a thorough comprehension of the natural drainage system of the area under treatment.* The region above the Palisades on the Hudson furnishes excellent illustration of these statements. The plateau fronts the river eastward with a bluff 300 feet high, and westward slopes gently to the Hackensack Valley. . . . All topographical conditions of unusual health seem here present, and yet malarial diseases abound. The reason of this will probably be found in the configuration of the rock. The dense basalt underlying the thin soil absorbs almost no water. Its surface, originally nearly level, was worn by glacial action into low, swelling ridges and shallow rock-basins, many of which, having no outlet, hold stagnant water as great saucers would. If the rock were either fissured or porous the height of the plateau would insure perfect under-drainage."

With the Palisades plateau the author now contrasts the Helderberg plateau, also situated near the Hudson River. Here, "an escarpment 1,000 feet high bounds, on the eastern side, the table-land, composed of horizontal limestone resting on shales. From the more level parts water does not pass off by surface-streams. Low undulations divide these areas into many separate basins, each draining toward its own centre, where a funnel-shaped opening in the limestone receives the disappearing flow, whose future course is subterranean. These basins are from a few acres to 300 or 400 in extent. When one covers about five square miles a pond is formed at the point of central drainage, finding outlet through fissures of the limestone below. The plateau's elevation insures that these waters sink at once many hundred feet, or escape in springs along the cliffs." Mr. Gardner then proceeds to show how—as at Sandusky, Ohio—this same Helderberg limestone may, *under different topographical conditions*, become one of the most powerful producers of disease.

A Formidable Arachnidan.—Dr. B. F. Pope, U. S. A., contributes to *Forest and Stream* some valuable "Notes on the Natural History of Southwestern Texas," from which we take the following account of the "vinagrone" (*big vinegar*, so called on account of the pungent secretion it ejects), an arachnidan found in the vicinity of Fort Stockton. In general appearance it resembles a large scorpion, though belonging to a different family. From the head to the commencement of the tail the adult vinagrone is full two inches long; in breadth it measures about three-quarters of an inch. The thorax and head are amalgamated, while the thorax and abdomen are separated by flexible tissue. The legs are six in number, all attached to the thorax. The trunk and head are protected by a single dorsal plate; the abdomen has sixteen distinct dorsal and ventral laminæ, which overlap; they would form continuous rings, were it not that they are curiously separated laterally by elastic tissue. This division of the abdominal rings affords considerable flexibility, and gives the insect the appearance of bearing about him an old-fashioned bellows. From the terminal, dorsal, and ventral plates is given off a series of rings, which, after the third one, are fused into a stiff spike or tail, that is usually three-fifths of the length of the entire body, and covered with short bristles like the legs. This is not a sting, nor does it seem to be the duct through which the secretion is ejected. It appears to be used principally as a posterior feeler, and sometimes as an aid to locomotion.

From the head are given off two powerful brachials, each having four articulations. They resemble the arms of a scorpion, and terminate in sharply-curved pincers. The threatening manner in which they are opened and stretched out, when the insect is enraged or is seeking for its prey, almost makes one shudder. But the brachia are not its only means of offense. Beneath the frontal plate are two long, incurvated fangs. Connected with these are two sacs, that, by pressure, exude drops of greenish liquid over the fangs, and in them undoubtedly resides the true venom of the insect.

Of the bite of this animal the author writes: "We have no good proof that the bite of the vinagrone would be fatal to man,

except perhaps as it might be supplemented by the shock of an excessive terror; but that it would be dangerous I think highly probable. As an experiment, I confined two of them in a small box with a large bat. The next morning the bat was dead, having been killed by them during the night, when it is supposed to be most agile and wary. I placed another unsavory specimen in a large bottle, in company with a large wasp and a tarantula. The vinagrone killed and devoured them both in short order."

In a later number of the same journal Dr. H. C. Yarrow writes that the vinagrone is quite well known to entomologists under the name of *Thelyphonus giganteus*, and that it is common in New Mexico and Arizona.

The Scandal of the Seal-Fishery.—Unless the governments of the countries which send out ships to the seal-fishery grounds speedily put some restrictions on the method now pursued, there will before long be no seals. In 1868 Dr. Robert Brown expressed his belief that, "supposing the sealing prosecuted with the same vigor as at present, before thirty years shall have passed away the seal-fishery, as a source of commerical revenue, will have come to a close." The Greenland seal-fishery is already "practically used up" and the sealers are now turning their attention to the coast of Newfoundland. A writer in *Nature* cites the London *Daily News*, to show what slaughter is made of the Newfoundland seals, and we learn that in one season four vessels secured 89,000 seals. To this add a like number of young ones left to die of starvation, and twenty per cent. as many mortally wounded and lost, and the aggregate amounts to over 200,000 seals! The writer in *Nature* suggests this subject of the destruction of the seal as a fitting one to occupy the minds of the advocates of the anti-vivisection laws, and the Society for the Prevention of Cruelty to Animals.

The Building-Stones of St. Lawrence County, New York.—From a statement by Mr. D. Minthorn, published in the *Engineering and Mining Journal*, it appears that in the northern portion of the State of New York may be found in abundance all the choicest varieties of marbles, granites, and other building-stones. Besides the common gray gneiss, he enumerates among the building-stones of St. Lawrence County several varieties, such as syenitic granite, many New England granites, a deep-green granite "mottled like the pedestals of Cheops." Then there are various pink, green, and dark-red porphyritic granites; and finally there are large masses of very compact gray and green granite, studded with garnets about half an inch apart. The varieties of marbles are very numerous, ranging from white limestone and dolomite and statuary marble to straw-colored, blue, drab, brown, black, yellow, and red variegated marbles; verd-antique also is represented; indeed, Mr. Minthorn is prepared to match any of the antique marbles with the products of the St. Lawrence County quarries. Adjoining the statuary-marble quarry is a deposit consisting partly of pagodite or Chinese figure-stone, and possessing sufficient hardness to take a polish, while at the same time it does not "chip out" when chiseled in sharp lines.

NOTES.

We have received from Conrad Meyer & Sons, of Philadelphia, a correction of the statement made by Mr. S. Austen Pierce, in our October number, that Jonas Chickering in 1837 "conceived the bold idea of constructing a [pianoforte] frame entirely of iron." The Messrs. Meyer now cite the official "report" of the jury of the Franklin Institute Exhibition of 1833, which mentions "an iron-framed square piano" exhibited by Conrad Meyer. Other testimony to the same effect is quoted by the Messrs. Meyer, who appear to make out a clear case of priority of invention. Having admitted this correction, we can afford no more space in the columns of the MONTHLY for the piano-frame controversy.

We have received from Mr. E. Berliner, Washington, a circular, with drawings, giving an account of certain of the author's discoveries and inventions in electricity. These are a contact telephone, an electric-spark telephone, and a method of telephonic transfer.

At New Cumberland, West Virginia, a fountain of natural gas is utilized for manufacturing fire-brick. This, says the *American Manufacturer*, is the first fire-brick ever burned without wood or coal. Fifty-five thousand bricks are made daily in nine

kilns. The gas furthermore supplies fuel for three engines, ten furnaces in the drying-house, and several dwellings—the latter obtaining in this way both light and heat. There remains withal a large surplus of gas, which is unused, except from the top of an escape-pipe, for illuminating the country around.

THE *Nation* is authority for the statement that the office of Director of the International Bureau of Weights and Measures in Paris has been offered to Prof. J. E. Hilgard, of the United States Coast Survey.

DIED, at Bonn, on September 13th, at the age of eighty-nine years, Jakob Nöggerath, for about fifty years Professor of Mineralogy in the university of that town. The deceased was a most assiduous student of mineralogy and geology, and his contributions to scientific literature were very voluminous.

MR. HENRY NEWTON, geologist, attached to Jenney's Black Hills Exploring Expedition, died at Deadwood City, August 5th, at the early age of thirty-two years. Mr. Newton was a graduate of the Columbia College School of Mines; later, Assistant Professor of Geology in the same institution; then he joined the Ohio Survey under Prof. Newberry; finally, two years ago, he became geologist of Prof. Jenney's Expedition to the Black Hills.

MR. R. A. PROCTOR, in excusing himself for not answering all the letters of inquiry he receives, gives the following account of his multifarious occupations: Seeing through the press three new works and four new editions, preparing two pamphlets, writing one translation of an 800-page book, and preparing four new works; writing articles for English and American magazines; lecturing occasionally; business correspondence with ten publishers; personal concerns; original research.

AT a meeting of the Paris Academy of Sciences, a note by L. Laliman was read, in which the author stated that he had discovered an insect which preys on the Phylloxera. This insect, or rather its larva—for M. Laliman had not seen the perfect insect—devours phylloxeras with great avidity, and the author saw as many as ninety-five disappearing in the space of ten minutes. The larva was found in the interstices of the leaf-galls, and sometimes in the substance of the galls. M. Laliman thinks he has seen the egg of this insect; it occurs on the underside of the leaf; but he has not seen it hatched. A member of the Academy, M. Balbiani, remarked that the fact observed by Laliman is not altogether new. The larva seen by him belongs to the genus *Syrphus*, or to some allied genus. The larvæ of *Syrphus* all prey on Aphides.

AN expedition, with aims similar to those of the "Woodruff Expedition," will sail from Havre, France, on the 15th of June, 1878. This expedition will be absent from France for eleven months. Of this time it is proposed to spend about six months and a half in excursions inland in America, North and South, the Pacific Archipelagos, Australia, Japan, China, British India, etc. The cost of passage is 17,000 francs per head.

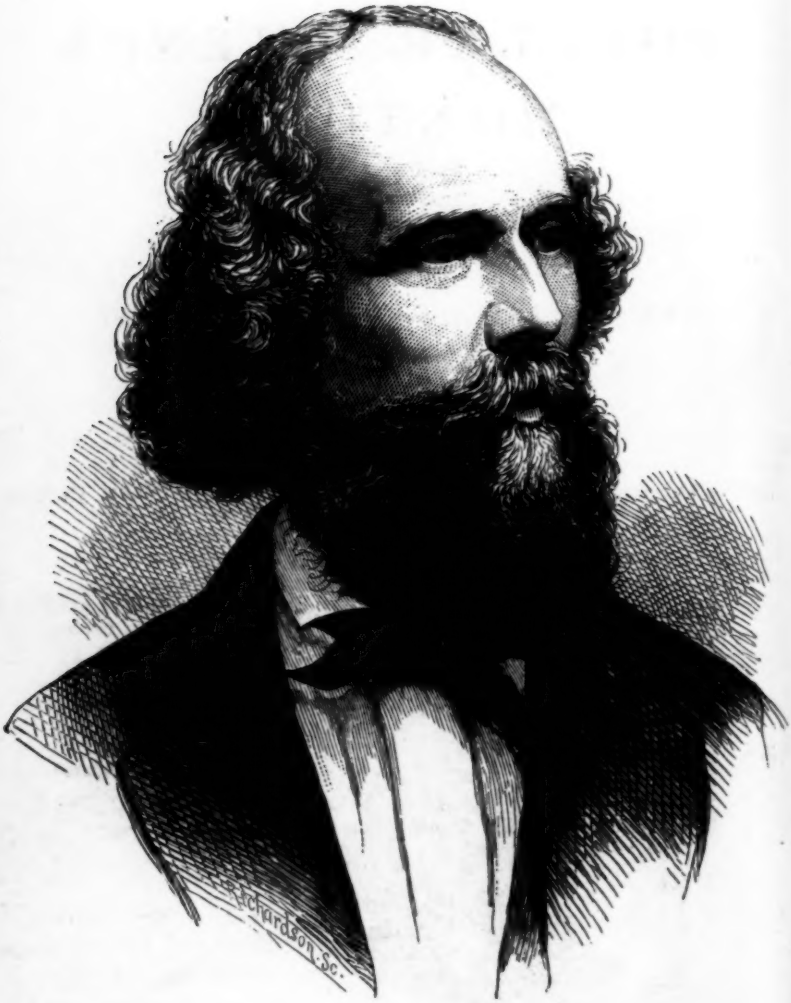
MR. RICHARD S. FLOYD, one of the trustees of the "Lick Trust," on his return to California, after an extended tour of foreign travel, during which he collected all the information he could with regard to the construction of great telescopes, expressed his belief that the best telescope for the Lick Observatory would be a refractor of the largest size. The cost of a suitable instrument, with object-glass of forty inches, would not, he thinks, exceed $150,000. But, in addition to the great refractor, Mr. Floyd would have in the observatory a reflector about four feet in diameter, with both silvered glass and speculum-metal mirrors. This would cost about $20,000.

A SERVICE of plate was recently presented in London to Señor Manuel Garcia "in recognition of the great services he has rendered alike to science and humanity by his important discovery of the laryngoscope."

ADVICES from Australia announce the total and sudden disappearance of a group of guano-islands—the Barker Islands—situate in latitude 14° south, and longitude 125° east, just off the northwest coast of Australia. In April last Mr. Fisher, a capitalist of Tasmania, who had obtained from the government the right of working the guano-deposits, visited their site with three steamships, but found there only a "waste of waters," and had to return empty. The Barker Islands are not mentioned in the "Imperial Gazetteer," nor are they indicated in the atlases.

THERE was exported from China to Europe, in the year 1875, the enormous amount of about sixty tons of human hair. This hair is ostensibly the product of the sweeping of barber-shops, but there is little doubt that much of it represents "pig-tails" feloniously snipped from their wearers' heads.

THE addition of cheese to the army and navy ration, in part substitution for salt meat, is advocated by a writer in the *Polytechnic Review*. The suggestion is a good one, the advantages of cheese being manifold: it is wholesome, highly nutritious, aids digestion, needs no cooking, and is easily handled and transported.



JOSEPH LE CONTE.